



## What's it Mean to be an Earn-A-Bike Instructor?

Welcome to Instructor Training!

### **Earn-A-Bike (EAB) Program Objectives**

- To provide an opportunity for students to earn used bicycles through their participation in the program.
- To teach students basic bike mechanics and bike safety skills, and the increased self-sufficiency that comes with having these skills.
- To provide a safe, supportive, respectful environment for all the participants.
- To provide a pre-vocational training experience, in which students learn the value of participation, productive work, punctuality and dependability.



In the course of doing all of the above, we are also helping students develop the following higher order thinking skills:

**Language** Use of specific vocabulary to communicate a technical concept.

**Systems** Understanding how the components of a system interact and function as a whole. Ability to identify what components make up a system.

**Process** Understanding how processes can be broken down into steps. Ability to enumerate the steps in a simple process.

**Problem-Solving** Diagnosing a problem and designing an effective approach to developing and testing solutions.

**Interpersonal Communication** Interacting effectively with “customers” and others at all levels of interpersonal relations.

Finally, the EAB program, through the training and role provided for volunteer instructors, creates an opportunity for older teens and adults to gain teaching experience in an inner city, multi-cultural setting.



## **Bikes Not Bombs Instructor Training Contract Rights and Responsibilities**

### **Bikes Not Bombs agrees to:**

- 1) Provide all volunteer instructors with eight to ten scheduled training sessions in which they will be taught basic bike repair and safety skills and introduced to the teaching model we use in the EAB Program.
- 2) Provide all volunteer instructors with a credit of \$2 per hour worked towards the purchase of used parts or bikes here at our Center. Credits are provided for the hours the instructors are in training as well as the hours they work as instructors. (However, if the trainee does not fulfill her/his commitment to teach 10 EAB sessions, s/he will NOT receive any credit for the hours in training.)
- 3) Provide a certificate of completion for the training once the material in all training sessions has been mastered, and to provide references and recommendations to prospective employers based upon a frank evaluation of the instructor's participation.

### **The Volunteer Instructor Trainee agrees to:**

- 1) Sign up for and attend at least four of the eight to ten initially scheduled Instructor Training Sessions, and to complete all sessions within six months (either by taking make up classes if they are available **or** by taking classes on Wednesday nights as available, **or** by participating as an assistant with an experienced instructor in an EAB session working on a system of the bike that was covered in a lesson you missed).
- 2) Commit to working as a volunteer instructor in at least ten EAB sessions (in addition to any training sessions) following your training.
- 3) Show up on time for any session signed up for, and stay for the whole session unless you've arranged otherwise with the instructor. Please call us and let us know if you are ever suddenly unable to attend a session you have committed to teach.
- 4) Record your hours accurately on your time sheet.
- 5) Wear a helmet and follow the safety practices we learn in our trainings whenever you are riding in a BNB ride **and** whenever you are riding to and from the Center.

I agree to fulfill the responsibilities outlined above.

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Volunteer Instructor Trainee

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Bikes Not Bombs



# Contents

## **The Braking System: Cable Tension — Spring Release ..... 2**

### **Part One - Planning ..... 2**

I. Objectives .....	2
II. Materials Needed.....	2
III. Setting .....	2
IV. Evaluation .....	2

### **Part Two - Activity Instructions ..... 3**

I. Tool Check! .....	3
II. Language Skills .....	3
III. System Understanding .....	4
IV. Process .....	4
Steps to Adjust Side-Pull Brakes .....	4
Steps to Adjust Center-Pull Brakes .....	5
V. Problem Solving/Diagnosis .....	6
VI. Review .....	6



## The Braking System: Cable Tension — Spring Release

### Part One - Planning

#### I. Objectives

- A. Students should be able to identify a bike with unsafe brakes.
- B. Students should be able to name the separate components of the brake system and describe how they interact as a whole.
- C. Students should be able to describe the major steps of the brake adjustment process.
- D. Students should be familiar with the smaller steps of each major step.
- E. Students should become more familiar with the physics concepts of friction and momentum.

#### II. Materials Needed

##### Demonstration Parts

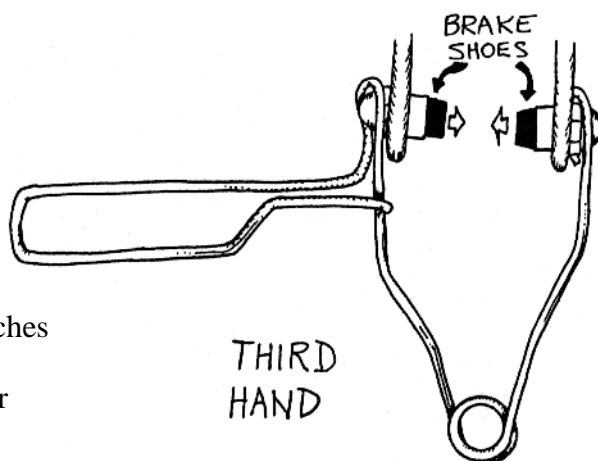
sidepull brake w/ cable and lever attached  
two brake shoes, unattached

##### Other Materials

lubricants  
rags

##### Tools

diagonal cutter  
brake wrenches  
pliers  
cable cutter  
fourth hand tool  
third hand tool  
8-9-10 mm combo wrenches  
T-handle screwdriver  
straight-edge screwdriver  
allen wrenches

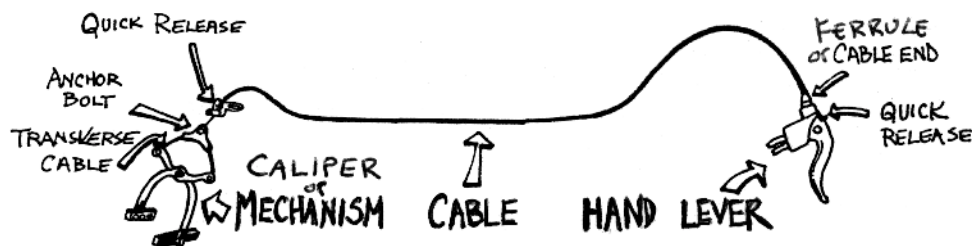


#### III. Setting

- A. Workshop, with tool benches, bike repair stand and bike storage.
- B. Outdoor, Test Ride — choose a nearby, paved spot that has no traffic. An empty parking lot or playground is ideal.

#### IV. Evaluation

- A. Teacher Observation During Work Session Rotate amongst the students you are working with. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her come up with a solution?
- B. Oral Review at end of work session.
  - 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) **Systems:** Can the student say what components are part of the system worked on? How do they function as a whole?
  - 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- C. Written Evaluation How well can student narrate what she did that day on her time sheet?

**The Three Sub-Units of a  
Brake System****Part Two - Activity Instructions**

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

**II. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get each student to point to/touch each of these parts on his/her bike & say the name.

**Main Parts**

lever  
cable  
housing  
caliper (brake arm)  
shoes & brake block  
spring

**Necessary Tools**

brake wrenches  
pliers  
cable cutter  
diagonal cutter  
fourth hand tool  
third hand tool  
8, 9, 10 mm combo wrenches  
T-handle screwdriver  
allen wrenches  
straight-edge screwdriver

**Minor Parts**

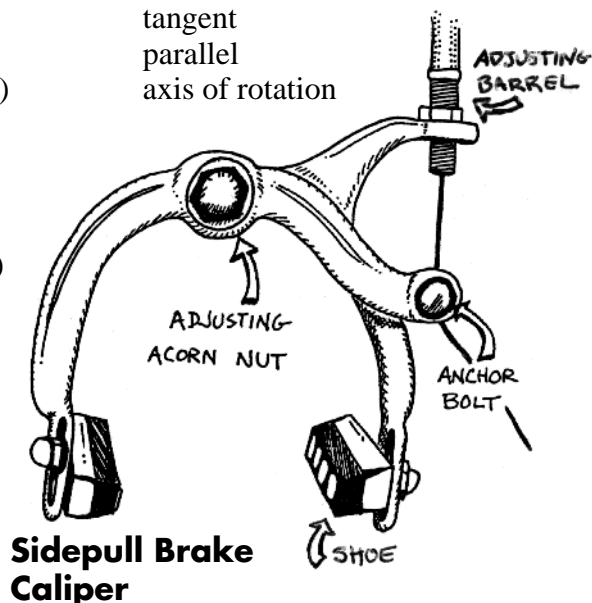
anchor bolt/pinch bolt  
housing stop  
lever strap  
cable end  
center bolt (Side Pull)  
mounting bolt (Center Pull)  
transverse cable  
ferrule  
adjusting barrel  
triangle/yoke  
(center Pull & Cantilever)

**Other Materials**

rags  
lubricants

**Math/Science Words**

tension  
friction  
force  
tangent  
parallel  
axis of rotation



**Note:** When working on any rim brake system, you have to make sure that the wheels are in good shape first. That means taking care of any problems with the rotational systems in the hubs, truing the wheels, and making sure the wheels are centered in the frame. Some other main words to remember are: axle, axle nut, axle washer, quick release skewer.

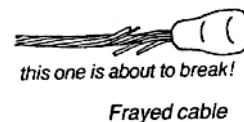


**III. System Understanding** Try different ways of phrasing this question: “What components are part of the brake system?” “How do they interact/affect each other/work together?” “How do they function as a whole?”

#### **IV. Process**

**A. Goal** — What’s a “good brake adjustment?” It stops you. What else?

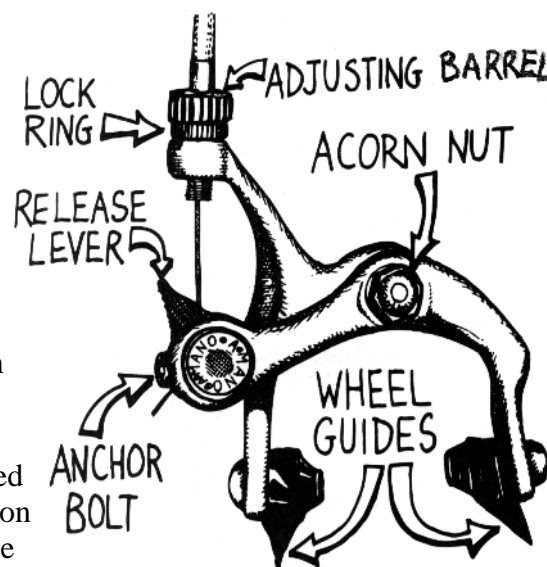
- Nothing about to break (cables not frayed, shoes not about to slip off of rim)
- Quick and Responsive — shoes get to rim fast, no “squishy” feeling
- Doesn’t squeak
- Will last a while (shoes not way worn down)
- Strong enough to stop you!
- Shoes aren’t hitting on rim, don’t rub as you pedal



When starting each of the steps below, also try to get across the goal of each step. “What’s the point of this step?”

**B. Steps to Adjust Side-Pull Brakes** — The process of adjusting sidepull brakes can be broken down into 12 steps. When teaching a group, go over the name of each step, as a list. Then describe/demonstrate each step to the students and have them each carry out that step on their bike before you move the group onto the next step. Alternately, if you have enough volunteer instructors, it’s great to work one instructor to two students, and try to keep each student working at her/his own pace.

- 1. Evaluate Condition** of existing parts, decide what to replace. Also, is the wheel centered in the frame, tightened to drop-outs, true, and not loose in hub? When working on any rim brake system, you also have to make sure that the wheels are in good shape first. That means taking care of any problems with the rotational systems in the hubs, truing the wheels, and making sure the wheels are centered in the frame.
- 2. Eliminate “Flop,” Front to Back Play** in calipers
  - a) Make sure that the brake caliper is firmly mounted to frame by tightening the nut on the back end of the center bolt (on side-pull brakes pivot bolt is same as the mounting bolt).
  - b) Make sure that the caliper arms are pressed together tightly enough to eliminate the “flop” or play between them, but not so tight the arms bind and don’t spring back away from the rim after releasing the brake lever (on a side-pull brake this is like a bearing/cone adjustment, lock nut serves same purpose). Lube these pivot points during this step.
  - c) Tool concepts fixed vs. adjustable wrenches, thin specialty wrenches vs. regular combination wrenches.
- 3. Shoe Placement on Rim** Up & Down — Set the brake shoe so that the top edge of brake block is even with the top edge of the braking surface on the rim. While the mounting bolt is loose, also take care of the shoe’s rotation around the mounting bolt. Do the initial Toeing.

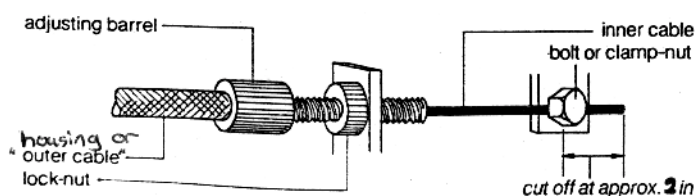






**B. Steps to Adjust Sidepull Brakes - continued**

4. **Disconnect Cable Anchor Bolt** and remove cable. Inspect cable at the spot where it has been flattened by the anchor bolt to make sure it is not frayed there. Grease cable, using steel wool 1st if necessary.
5. **Lubrication** — oil the cables (grease 'em if you are taking them out of housing, otherwise drip oil into housing — rotate bike around and make gravity your friend!), and the pivot points in calipers and levers.
6. **Tighten Brake levers** on handlebars — Think about the rider's wrists, and the size of rider's grip (if there is a grip adjust screw). See Barnett's manual for standard positioning diagram.
7. **Seat cable end in brake lever** show the 2 types of cable end, and widths of cable.
8. **Cable tightness** Demonstrate relationship between cable length and closeness of shoes to rim. Pre-stretch new cables. After showing cable tightening, talk about barrel adjusters.

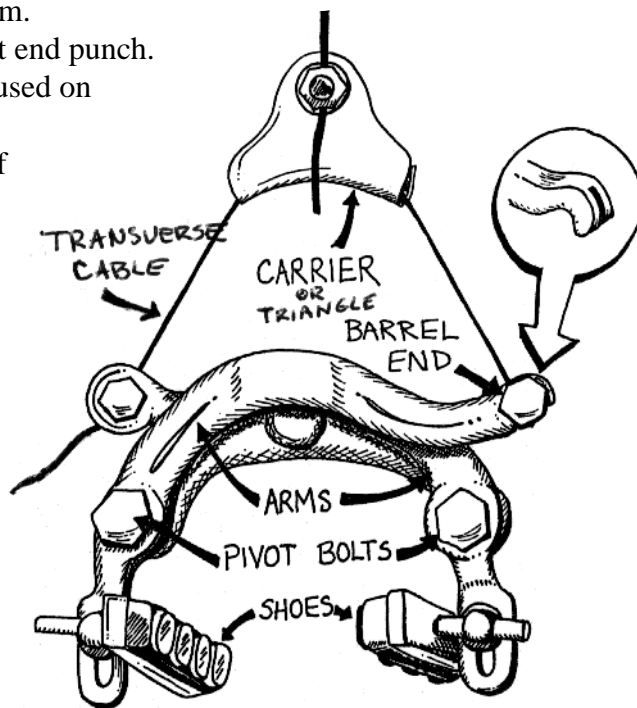


**Barrel Adjuster**

9. **Toeing** Final toeing. Set following edge of brake block 0.5 to 1.5 mm away from rim when leading edge is just touching rim.
10. **Centering** Crude method — with a hammer and flat end punch.  
Elegant method — with two specialty brake levers, used on center bolt.
11. **Clean off the rims and shoes** use a clean rag and, if necessary, some alcohol, to get off all grease (Why no lube wanted on these surfaces??? In this case, *friction* is our friend!)
12. **Test Ride.**

**C. Steps to Adjust Center-Pull Brakes** — Adjusting center-pull brakes is almost the same as side-pull brakes, with the following exceptions:

1. **Evaluate Condition** of existing parts. Same.
2. **Eliminate "Flop," Front to Back Play** in calipers by assuring that caliper is firmly mounted to frame. Center-pull brakes have one mounting bolt and two pivot bolts. Lube these pivot points during this step.



**C. Steps to Adjust Centerpull Brakes - continued**

3. **Shoe Placement on Rim** You must center the caliper before placing shoes. On a center-pull brake, changing the centering moves the brake shoes up or down. Set the brake shoe so that the bottom edge of brake block is even with the bottom edge of the braking surface on the rim (any guesses why this is different than with sidepulls?) Check: Up & Down, Rotating around mounting bolt, and Toeing
4. **Disconnect Cable Anchor Bolt** Same.
5. **Lubrication** Same.
6. **Tighten Brake levers on handlebars** Same.
7. **Seat cable end in brake lever** Show two types of cable end, various widths of cable.
8. **Cable tightness** Same, except that you are tightening the anchor bolt on the cable triangle, and must make sure that the transverse cable is seated correctly and in good shape.
9. **Toeing** Same.
10. **Final Centering** gentle taps with a hammer and flat end punch. Check shoe placement again.
11. **Clean off the rims and shoes** use a clean rag and, if necessary., some alcohol, to get off all grease (Why no lube wanted on these surfaces??? In this case, Friction is our friend!)
12. **Test Ride** Same.

**V. Problem Solving/Diagnosis**

1. If a sidepull brake caliper won't open back up (move away from the rim) after you release the lever, what are the possible causes of this problem? (cable stuck in housing, or caliper arms pressed too tightly together by the nuts on the centerbolt) How can you find out which of the possible causes is the right one?
2. What other problem solving did we do?

**VI. Review**

1. What are the names of the parts of the brake system? How do they function together? What other parts of the bike really work as part of the brake system as well?
2. What order did we do the steps in?
3. Can we change the order?
4. What specialty tools did we use? What common mechanics tools?

**VII. Clean Up****VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.





# Contents

<b>Cantilever Brakes</b> .....	2
<b>Part One - Planning</b> .....	2
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2
<b>Part Two - Activity Instructions</b> .....	3
I. Tool Check! .....	3
II. Process .....	3
Steps to Overhauling and Adjusting Cantilever Brakes .....	3
Adjust the brakes .....	4
III. Language Skills .....	6
IV. System Understanding .....	6
V. Problem Solving/Diagnosis .....	6
VI. Review .....	6

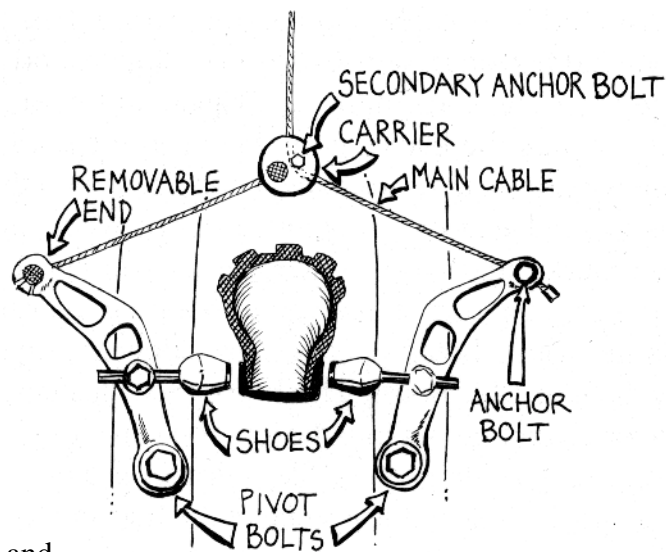


## Cantilever Brakes

### Part One - Planning

#### I. Objectives

- A. Student can identify a pair of cantilever brakes in need of adjustment.
- B. Student can name the different parts of various cantilever brakes and the tools used to fix them.
- C. Student becomes more familiar with concepts of parallel and perpendicular.
- D. Student becomes more familiar with the physics concepts of friction, surface area, and leverage.
- E. Student can describe all the major steps for assembly and adjustment of cantilever brakes.



#### II. Materials Needed

##### **Demonstration Parts**

Fork w/ cantilever posts  
Full set of "canti" brakes  
Brake lever  
Cable  
Housing

##### **Tools**

Box End and Adj. Wrenches  
Allen Wrenches  
Screwdrivers  
Fourth Hand

##### **Other Materials**

Grease  
Oil  
Lock tight  
Rags and Aprons  
Sand Paper  
Degreaser

**III. Setting** Workshop, with tool benches, bike repair stand, and bike storage.

#### IV. Evaluation

- A. Teacher Observation During Work Session Rotate amongst the students as you work. Observe for general mechanics skills (e.g. tool confidence and body position during tool use), work habits (e.g. keeping parts orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help him or her come up with a solution?
- B. Oral review at end of work session
  - 1) Language: How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) Systems: Can the student say what components are part of the system on which we worked? How do the components function as a whole?
  - 3) Process: How many of the steps of the process can students name? Can they get the steps in correct order?
- C. Written Evaluation How well can student narrate what they did that day on their time sheet?



## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### II. Process

A. **Goal**— What are we trying to get done when we overhaul and adjust cantilever brakes? What does it mean to have properly adjusted brakes? Have you ever ridden a bike where the brakes were too loose? Too tight? What happened? How do the brakes affect the performance of the bicycle? What other factors may affect the performance of your brakes?

A well done brake adjustment or overhaul makes sure that:

- The hub of the wheel is properly adjusted.
- The wheel is true.
- The brake pads touch evenly on the rim and do not rub while brakes are not engaged.
- The brakes are not too loose.
- Both brake pads are “Toed” evenly.
- Brakes do not squeal!!!

B. **Steps to Overhauling and Adjusting Cantilever Brakes**— Go over each step of the process. Then, describe each step to the students and have them each carry out that step on their bikes before you move the group onto the next step.

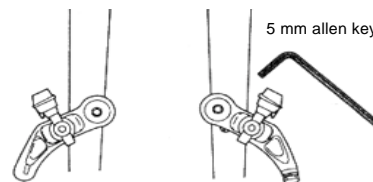
**1. Evaluate condition** of as many parts as possible before disassembly.

- a. Check the adjustment of the hub. If your hub is loose then it is impossible for the rim to move through a fixed circle (it can wobble from side to side). If the rim does not move through a fixed circle the brakes cannot be properly adjusted.
- b. Check if wheel is true. If the wheel is not true it is impossible to align the brake pads with the rim.
- c. Pads? Are the pads worn or worn unevenly? Can they be used again or must they be replaced?
- d. Cantilever arms? Are the springs in good condition? What about the spring casings?
- e. Brake levers? Do they pivot easily? Are any parts broken or missing?
- f. Cables and housing? Is the cable frayed or rusted? Is the housing cracked?

**2. Decide if brakes need to be disassembled and readjusted.** If all parts of the brakes seem to be in good condition, you can skip to #8 and begin the process of adjustment.

**3. Disassemble** the brakes.

- a. Unlock transverse cable from non-drive side cantilever arm by removing the ball end of the transverse cable from its mount (squeeze the brake arms together to give you cable slack to do this).
- b. Unlock drive side end of the transverse cable by unscrewing the anchor bolt and set transverse cable aside.
- c. Loosen and remove cantilever post bolts. These are the bolts around which the cantilever arm pivots. Remember, once these bolts are removed all the parts of the brake are loose and can fall on the floor. Please use caution. The parts you should now have taken off the bike are the cantilever post bolt, a washer, the cantilever arm, the spring, and the spring casing.



**3. Disassemble** the brakes (continued)

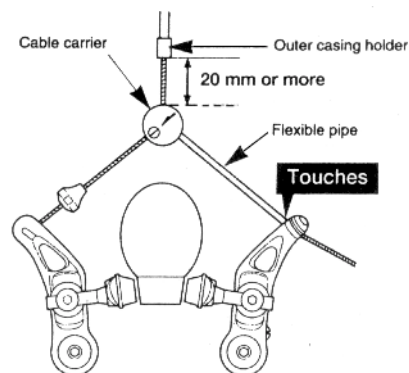
- d. If cables are frayed, rusted or broken, loosen and remove cable hanger. This is the small metal hanger that the transverse cable went through. Now, remove the cable housing and inspect it for rust or breakage.
- e. Remove the brake cable from the brake lever. Do this by looking underneath the brake lever and finding the ball-end of the brake cable. Align the “open” slot of both your barrel adjuster and barrel adjuster lock nut with the open end of the brake lever and remove the cable.

**4. Clean and Inspect** all the parts that have been removed.

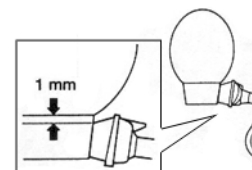
- a. Brake pads - Are they worn unevenly or worn too much?
- b. Cantilever arms, springs, and spring casing - rusty, bent/distorted or cracked?
- c. Cables and housing - Look for fraying, rust, and breakage.
- d. Brake lever - bent?

**5. Replace Parts** as necessary**6. Reassemble**- This is the same as disassembly only in reverse. If you are installing a new brake cable, tighten it enough so that the shoes are against the rim. Then squeeze the brake lever as hard as you can 10 times. The cable should stretch significantly. Then go ahead with the adjustment.**7. Adjust** the brakes. This process is the same for both front and rear brakes.

- a. Make sure that there is at least 20 mm of cable between the end of the cable housing (the housing stop or cable hanger) and the cable carrier (see diagram).
- b. Use the 4th hand tool to tighten the cable so that the brake pads are about 1-2 mm away from the rim when the barrel adjuster is screwed most of the way in. Then unscrew barrel adjuster six full turns.
- c. On the non-drive side cantilever arm loosen the bolt which holds the transverse cable and using a 4th Hand tool, tighten the cable until the brake pads are touching the rim firmly.
- d. Depending on how the brake pads are attached to the cantilever arm, loosen the pad slightly; enough that you can move it so the pad surface hits flat and centered on the rim.



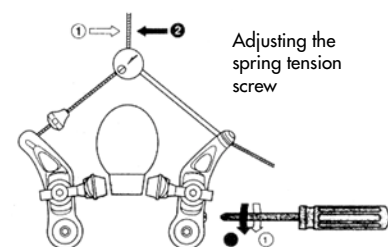
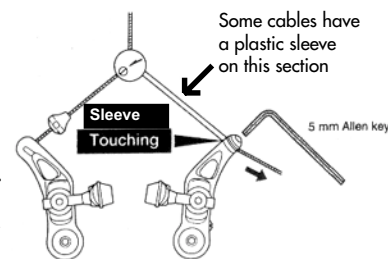
- e. Leaving the pad slightly loose add two to three millimeters of “toe” to each pad. This means that the front of pad should remain touching the rim evenly and you lift the rear of the pad slightly away from the rim so that when the brakes are adjusted the front of the brake pad will strike the rim first, thus eliminating a lot of vibration and squeaking. Once you’ve added the two or three millimeters of toe to each pad tighten down the pads as tight as you can, taking care not to let the pads rotate out of alignment in any of the three directions they could move.



- f. At this time the front ends of the pads should be touching the wheel hard enough so that the wheel can’t move and both pads should be toed properly. Make sure that your brake pads are tight enough by squeezing the brake lever and making sure that the pads don’t change their position.

**7. Adjust** the brakes (continued)

- g. Now screw the barrel adjuster back into the brake lever, thus loosening the tension of the brake cable and allowing the brake pads to fall away from the rim.
- h. Adjust cantilever spring tension. When you screw in the barrel adjuster and let the brake pads pull away from the rim, sometimes (most of the time) the cantilever arms will not pull evenly away from the rim. This means that the pads will not strike the rim at the same time, causing the wheel to eventually go out of true. Look at the brake pads and determine which one is closer to the rim and which is farther. If you increase the spring tension on the side which is closer to the rim, the pad will in turn pull farther away from the rim, centering the two pads on either side of the rim. Or, if you loosen the spring tension of the side that is farther away from the rim, it will pull closer in while the opposite side will pull further from the rim, achieving the same centering effect.



On many of the new cantilever brakes there are spring tension adjustment screws on the outside of the cantilever arms. If you screw in the adjustment screw it will push on the end of the spring coil, coiling it up tighter and adding tension to the spring, thereby pulling the cantilever arm and brake pad farther away from the rim. If you unscrew that adjuster screw the spring tension will be lessened and the cantilever arm and brake pad will fall in towards the rim. On other types of cantilever brakes there may be adjuster bolts that the spring threads into, and on some older types of brakes there is no spring adjustment at all. You may just have to bend the spring with your hand. Determine how to adjust your spring tension and do it so the brake pads are equidistant from the rim.

- i. Now squeeze the brake lever a few times to stretch the cable and feel whether or not the brakes are tight enough. To tighten the brakes unscrew the barrel adjuster until the brakes feel tight enough and lock down the barrel adjuster lock nut. If the brakes feel “mushy,” i.e. when you squeeze the brake lever there is a lot of give even when the pads are firmly touching the rim, you have not set the pads so that they are hitting the rim evenly and at the same time.
- i. Well, you’re done. Just remember, cantilever brakes are some of the hardest brakes to properly assemble and adjust. That means that it may take you more than once or twice or even five times to get the adjustment right. Don’t fret, you’ll get it eventually!!

**III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get the students to touch each of these parts on their bikes & say the name.

**Main Part**

Pads  
Springs  
Cantilever arms  
Bosses/posts  
Transverse cable

**Main Part**

Lever  
Cable  
Housing

**Necessary Tools**

Pliers  
Box Wrenches  
Allen Wrenches  
Screw Drivers  
4th hand

**Other Materials**

Grease  
Oil  
Locktight  
Rags and aprons  
Sand paper of file  
Degreaser spray

**Math Words**

Parallel  
Perpendicular  
Friction  
Leverage

**IV. System Understanding** Try different ways of phrasing this question.

What components are part of the Cantilever Brake System? How do they interact/affect each other/work together?  
How do they function as a whole?

**V. Problem Solving/Diagnosis**

1. What does it mean when your brakes aren't tight enough to stop you/too tight and your wheel won't turn?
2. How can you tell if you need an overhaul or just an adjustment?
3. If brakes become loose soon after you adjusted them what could that mean?
4. What other problem solving did we do?

**VI. Review****VII. Clean Up**

**VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

<b>Rear Derailleurs .....</b>	<b>2</b>
<b>Part One - Planning .....</b>	<b>2</b>
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2
<b>Part Two - Activity Instructions .....</b>	<b>3</b>
I. Tool Check! .....	3
II. Process .....	3
Steps to Installing and Adjusting a Rear Derailleur .....	3
Disassemble .....	4
Reassemble .....	5
Adjust your Rear Derailleur System .....	5
Adjust Your Shifting .....	7
III. Language Skills .....	8
IV. System Understanding .....	8
V. Problem Solving/Diagnosis .....	9
VI. Review .....	9



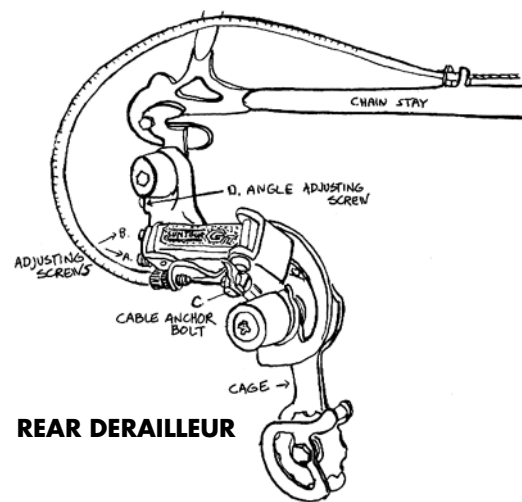


## Rear Derailleurs

### Part One - Planning

#### I. Objectives

- A. Student can identify a rear derailleur in need of adjustment.
- B. Student can name the parts of the rear derailleur system and the tools used on it.
- C. Student becomes more familiar with the math concepts of perpendicular and parallel.
- D. Student becomes more familiar with the physics concepts of friction and force.
- E. Student can describe all the major steps of rear derailleur installation and adjustment.
- F. Student can follow all the steps of derailleur assembly and adjustment.



#### II. Materials Needed

##### Demonstration Parts

Rear Der. complete w/guts not attached to bike  
Shift Lever  
Indexing and Non-Indexing  
Cable and Housing

##### Tools

Allen Wrenches  
Fourth Hand  
Flat ended screwdriver  
Phillips Screwdriver  
Box Wrenches

##### Other Materials

Grease  
Penetrating Oil  
Rags  
Rubber Gloves  
Ball Point Pen

**III. Setting** Workshop, with tool benches, bike repair stand and bike storage.

#### IV. Evaluation

- A. Teacher Observation During Work Session** Rotate amongst the students as you work. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her come up with a solution?
- B. Oral Review at end of work session.**
- 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) **Systems:** Can the student say what components are part of the system worked on? How do they function as a whole?
  - 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- C. Written Evaluation** How well can student narrate what she did that day on her time sheet?



## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### II. Process

**A. Goal** — What are we trying to get done when we install and adjust a rear derailleur? Have you ever ridden a bike where gears were messed up or the bike didn't shift right? What can happen? How does this effect your riding? How hard it is to pedal? The main purposes of the bike's rear derailleur system are: 1) To keep proper chain tension at all times, 2) to smoothly and easily change gears while riding without the chain falling into the spokes or the frame. A well done rear derailleur adjustment makes sure that:

- The chain tension is consistent in all of the bicycle's gear combinations.
- The bicycle shifts easily and smoothly through all of the gears.
- The chain does not fall off, into either the frame or the spokes, when shifting gears.

**B. Steps to Installing and Adjusting a Rear Derailleur** — Go over the names of each step, as a list. Then describe each step to the students and have them each carry out that step on their bikes before you move the group onto the next step.

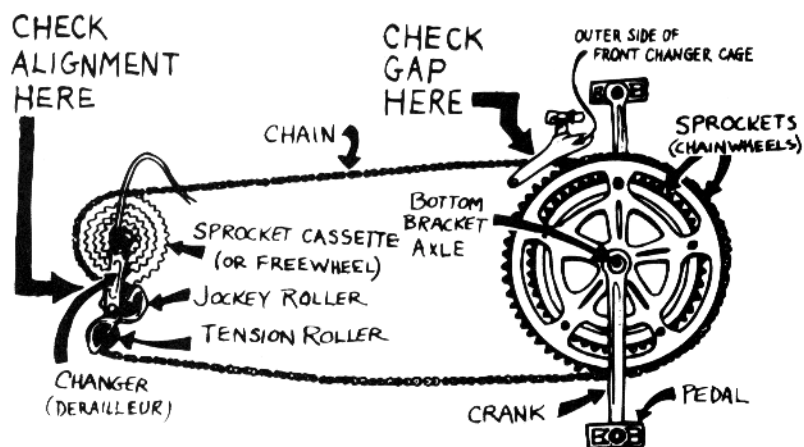
**1. Evaluate Condition** of as many parts as possible before you take anything apart.

a) Check Adjustment by pedaling the bike and using the shift lever to shift the rear derailleur. Does it shift smoothly? Does the chain fall off on either side of the rear gear cluster? Look at the derailleur from the rear. Is it bent? Can you push or pull the derailleur into the spokes or frame?

b) Derailleur hanger In addition to the derailleur itself, the hanger that the derailleur is attached to also can get bent. This will keep the derailleur from lining up with the cogs and keep the chain from shifting improperly.

c) Cables and housing OK? are they too short or too long? rusted, cracked or frayed? The proper function of a derailleur depends on the cable being able to move freely and easily through the housing.

d) Shifters pivot easily and are not too loose?



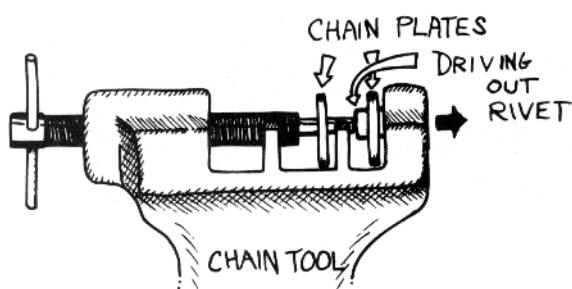
**1. Evaluate Condition** - continued

- e) Is the chain stretched? Twelve links (24 pins) of a new, unstretched chain will measure exactly 12 inches. If when you measure 12 links (lay a ruler along the straight section of the chain while it is pulled taught) they are less than 12 1/16 inches long, your chain is fine. If it's stretched 1/16 of an inch, replace the chain. A chain stretched more than 1/16th of an inch over 12 links will have begun to wear down the teeth of the rear gear cogs, and you will have to replace the cogs along with the chain (a new chain will probably skip on the old, worn down cogs). You can usually use a stretched chain without it's slipping on the cogs up to 1/8th to 3/16ths of an inch of stretch. After that the chain will begin to slip even over the cogs of the gears it's worn out. For instructions on removing the rear gear cluster (cassette or freewheel) see the Hubs Chapter.

2. **Decide if Derailleur System Needs to be Disassembled** If you can get a good adjustment (no grinding, it shifts well, and the chain doesn't fall into the spokes or the frame), then the derailleur is in good shape as is the cable and the housing. If your goal is just to get the bike ready, skip to step 7 and try an adjustment. If you want to teach the disassembly anyway, go on to step 3.

**3. Disassemble**

- a) Unlock the shifter cable from the derailleur On the underneath side of the derailleur find the anchor bolt that holds the shift cable. Loosen that bolt.



- b) Break the chain with a chain tool In order to remove the derailleur from the bike its necessary to "break" the chain, i.e. open up a link by pushing a pin most of the way out. Just remember, DON'T push the chain pin all the way out!! That's the pin you'll use to put the chain back together again. Remember which side of the chain was Up at the point where you break it. Some people think that because chains wear in conjunction with the rear cogs, if you put the chain on upside down from how it was on before you may get a lot of slipping in the gears or chain suck.

- c) Remove Derailleur Depending on what kind of derailleur you are dealing with this step may mean that you use an allen wrench to unscrew the derailleur from the hanger or you may have to use a wrench to loosen a bolt that holds both the hanger and the derailleur in the rear drop outs of the bike.

- d) Remove cable and housing and place all items on a flat, uncluttered surface in the order in which you removed them.

4. **Clean and Inspect** all the surfaces and threads — rub them with a rag with some light degreaser or penetrating oil.

- a) Broken or stuck Jockey Wheels? these are the two wheels on the derailleur swing arm.  
b) Swing Arm Bent? make sure the derailleur swing arm which holds both jockey wheels isn't bent or out of line.  
c) Springs are all springs on the derailleur still functioning?  
d) Cables and Housing Is the cable rusted or frayed? Is the housing rusted or broken? will the cable move easily through the housing? Will the end of the housing fit back into the housing ferrule?



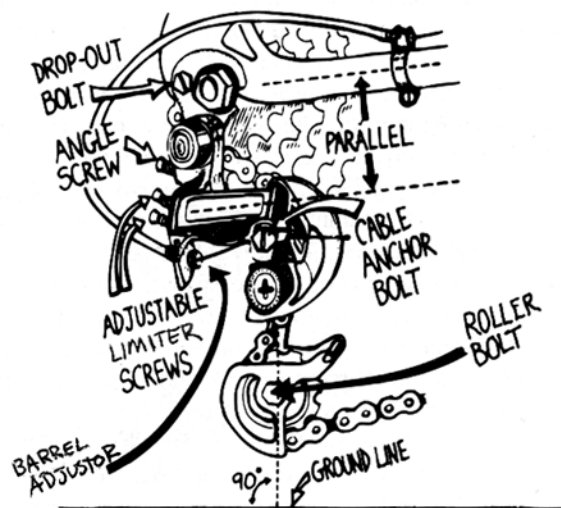
5. **Replace Parts** as necessary. Most of the time the parts that need replacing are the cable and the housing, as these are the parts where grease and grime tend to collect. Sometimes the derailleur itself is bent or broken and it's time to get a new one.
6. **Reassemble** this is just disassembly in reverse.
- a) **Grease the cables** put a little bit of grease or heavy weight oil on the cables whether their new or old. This prevents rust and allows the smooth movement of the cable in the housing.
  - b) **Check your Hanger Alignment**
    - On those bikes that have threads in derailleur hangers you can use a "Derailleur Hanger Alignment Tool" to check or change the alignment.
    - If the derailleur has its own hanger and bolts to the drop out, this step is not necessary.
  - c) **Install derailleur**
  - d) **Reinstall chain** making sure it gets threaded back through the derailleurs and rear cogs in the correct order (look at an installed chain on another bike if you are not sure).
  - e) The rest of reassembly is part of the adjustment process.

## 7. **Adjust your Rear Derailleur System**

- a) **Set your Limiter Screws** Remember, derailleurs are built to pivot from side to side. They are not built to automatically know how far they should pivot. This is why we invented limiter screws. If you've ever had your chain fall into your spokes or get trapped in between your gears and the frame you know what its like to have misadjusted limit screws.

- 1) Look down at the derailleur and find two screws one marked (H)igh and the other marked (L)ow. These are your limit screws. They have nothing to do with have the chain shifts from one cog to another, except for the innermost and outermost cogs. This is because these screws control how far the derailleur can travel from side to side.

- 2) Holding your index finger against the frame and your thumb against the derailleur, begin pedaling the bike and push the derailleur with your thumb all the way as far as you can in towards the spokes. If the chain passes the edge of the biggest cog and falls into spokes then the (L)imiter screw is not screwed in far enough, thus allowing the derailleur to pass beyond the largest chainring (and possibly into the spokes!). If the chain will not shift onto the largest cog, then your (L)imiter screw is screwed in too far. When your (L)ow gear limiter screw is set correctly, the chain should move all the way onto the largest cog, but not fall into the spokes. At that point, the jockey wheels should be in line with the largest chain ring and there should be NO!!!! grinding sounds while you pedal the bike.



**7.a) Set your limit Screws** (continued)

- 3) Now take your hand off the derailleur and let it fall back into the highest gear as you pedal the bike. Your (H)igh gear limiter screw should keep the chain from passing beyond the smallest cog and falling into the frame. It should also allow that the chain to run smoothly on the highest gear (on the smallest rear cog). Try as hard as you can to pull the derailleur so that the chain would fall into the frame. If the chain does fall into the frame your (H)igh gear limiter screw needs to be screwed in a little farther in order to limit the derailleurs movement towards the frame. If the derailleur holds its position and the chain does not grind off the gear your (H)igh limiter screw is All Set!

**b) Attach the derailleur cable**

- 1) Make sure that the shifter is all the way down i.e. its in the position of the highest gear, where it does not pull on the cable at all.
- 2) Route cable properly, making sure that the ball end fits snugly into the shifter and that the cable runs the proper route from the shifter to the derailleur. This task may sound easy but it can be deceiving. In some cases the cable may run over or under the bottom bracket or may run with or without housing at different spots. Always try to remember how the cables were run when you first saw the bike.
- 3) Make sure that all barrel adjusters have space to adjust in both directions (usually there is only one on the back side of the derailleur that the cable routes through though on some of the newer bikes there is a second one on the either the down tube or as a part of the shifter). If your barrel adjusters are either screwed in all the way or out all the way you won't have the ability to adjust cable tension once you attach the cable.
- 4) Make sure derailleur is in the highest gear (i.e. your chain is on the smallest rear cog). With your shifters in the highest gear and your derailleur in the highest gear, you make sure that you are not going to end up with a lot of extra cable slack once you attach the cable.
- 5) Attach Cable Look carefully at the derailleur cable anchor bolt and the surface of the derailleur against which the cable clamps. Usually you can tell how the cable wants to be routed by looking for a slight groove in either the bolt or the derailleur itself. This groove indicates what line the cable should follow. Nine times out of ten this will be a straight line out of the barrel adjuster. Now pull the cable through and bolt it down making sure to only pull the cable hand-tight. If you use a fourth hand or pull the cable tight with a pair of pliers, the cable will be too tight and the derailleur will be unable to shift into the highest gear.
- 6) If you are using a new cable, grab it on a stretch where it's outside of the housing and pull on it as hard as you can, several times. This stretches the cable so that once we've adjusted our shifting we won't lose our adjustment because of our cable stretching. Be sure to stretch it as hard as you can. Don't worry, we've never met anyone who ever broke a cable. Sometimes the cable will slip out from behind the anchor bolt on the derailleur, but that's just because you didn't tighten the bolt down enough. After you've stretched the cable repeat step 5) and reattach it hand-tight.



c) **Adjust Your Shifting** This process is slightly different for index shifting than it is for friction shifting. Index shifting is the one “click,” one shift mechanism. It’s made so that there should be no guess work when it comes to finding your gear. Friction shifting doesn’t have any “clicks.” You just have to look around for the gear you want. The positive aspect of friction shifting is that if your shifting isn’t dependent on these “clicks”. If your cable tension and “clicks” are not completely synchronized your bike won’t shift properly. With friction shifting, even if you don’t have perfect cable tension you can still find the proper gear.

- 1) With friction shifters once you’ve set your limit screws and attached your cable most of your work is done. Now all you have to do is make sure your cable has enough tension on it. You should be all set. Try shifting the bike making sure that you don’t have to push the shifter beyond its limit to get the bike into the lowest gear.
- 2) Index shifters are a little more difficult. You must fine-tune the cable tension. After pulling the cable hand-tight and attaching the cable to the derailleur with the anchor bolt, then, while pedaling the bike, shift the shifter up until you hear the first click. Now unscrew (or screw in!) your barrel adjuster until the chain shifts up onto the second cog, and the center of the chain is directly over the center of the cogs (as you look at the assembly from the rear of the bike). In theory, you now have the correct cable tension to make each shift up to the next cog happen snappily with each next click. With the shifter, move the chain up one to each gear cog. Do this all the way up to the lowest gear and back down again. adjust your chain tension with the barrel adjuster if you hear any grinding sounds in each gear, or if the chain moves sluggishly. NOTE: unscrewing the barrel adjuster moves the derailleur (and thus the chain) in towards the wheel, screwing in the barrel adjuster moves the derailleur out away from the wheel - why? (Hint: are you making the housing longer or shorter relative to the cable?) Now you should be All Set!!

\*With these newfangled grip shifters you need to shift just a little bit past the click each time in order to get a proper adjustment.\*

**8. Test Ride** All gear systems can behave differently when you are actually riding the bike than they do when you are testing them with the bike up in a workstand. (What are some of the possible reasons for this?) Put a screw driver that fits your limiter screws and the tool needed to loosen the anchor bolt in you pocket and go out for a brief ride.

- a) Put chain on large chainring and smallest cog in back, and try shifting back and forth from the smallest to the next cog at least five times.
  - i. If the chain falls off on the outside, turn the (H)igh gear limiter screw in 1/4 turn and try again.
  - ii. If the chain doesn’t go smoothly down onto the smallest cog, it could be that the cable is too tight, or that the limiter screw is too far in. How can you tell which item to adjust? (You can see the bottom of the limiter screw and check whether it is bottomed out against the stop on the derailleur. If not, it is excess cable tension that is keeping the derailleur from moving the chain down onto the smallest chainring.) If it’s the cable tension, you need to loosen the cable using the barrel adjuster (you *loosen* the cable by *screwing in* the barrel adjuster). Screw it in one turn and try again.

**8. Test Ride** - continued

- b) Put chain on small chainring and smallest cog in back, and try shifting back and forth from the largest to the next cog at least five times. Now the chain is pulling at a slightly different angle, and you may need to repeat the adjustments as above.
- c) Put chain on the smallest chainring and *biggest* cog in back, and try shifting back and forth from the biggest to next cog at least five times.
  - i. If the chain falls off on the inside, turn the (L)ow gear limiter screw in 1/4 turn and try again.
- d) Put chain on biggest chainring and *biggest* cog in back, and try shifting back and forth from the largest cog to the next cog down at least five times. Now the chain is pulling at a slightly different angle, and you may need to repeat the adjustments as above.

All done!

**III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get the students to put their finger on each of these parts on their bikes & say the name.

**Main Parts - Derailleur**

Jockey Wheels  
Swing Arm  
Limiter Screws  
Barrel Adjuster

**Necessary Tools**

Allen Wrenches  
Box End Wrenches  
Flat Head Screwdriver  
Phillips Screwdriver  
Cable Cutters  
Housing Cutters  
Chain Tool

**Other Materials**

Grease  
Light oil  
Rags

**Math/Physics Words**

Parallel  
Perpendicular  
Friction  
Gear Ratio

**Note:** Mention here the other systems you end up dealing with in the course of this lesson (wheels, steering, etc.), and include the main words to remember:

**IV. System Understanding** Try different ways of phrasing these questions.

What components are part of this system? How do they interact/affect each other/work together? How do they function as a whole? Why can the derailleur system be described as a “cable tension, spring release” system? When you pull on the shift lever, the lever pulls on the cable and moves the derailleur in towards the wheel. Can you push with a cable (try it with a cable extended between two students!)? When you release the tension on the cable by moving the shifter back to its original position, what pushes the derailleur back down?





**V. Problem Solving/Diagnosis**

1. What does it mean if your limiter screws are properly set but the chain doesn't shift into the highest gear?
2. How can you tell if you need an overhaul?
3. If the bike stopped shifting properly soon after you made your adjustment what could have happened?
4. What other problem solving did we do?

**VI. Review**

**VII. Clean Up**

**VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

<b>Front Derailleurs</b> .....	2
<b>Part One - Planning</b> .....	2
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2
<b>Part Two - Activity Instructions</b> .....	3
Steps to Adjusting and Replacing Front Derailleurs .....	3
Disassemble .....	4
Reassemble .....	5
Adjust the front derailleur .....	6
III. Language Skills .....	7
IV. System Understanding .....	7
V. Problem Solving/Diagnosis .....	7
VI. Review .....	7

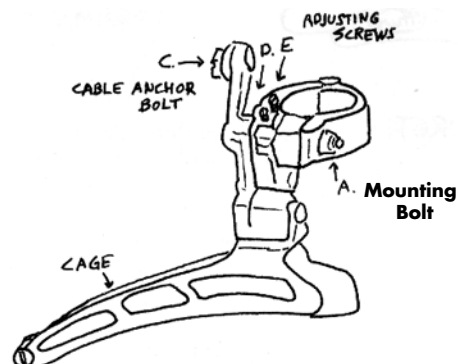


## Front Derailleurs

### Part One - Planning

#### I. Objectives

- A. Student can identify a front derailleur in need of adjustment.
- B. Student can name the parts of the front derailleur system and the tools used on it.
- C. Student becomes more familiar with the math concepts of perpendicular and parallel.
- D. Student becomes more familiar with the physics concepts of friction, force and tension.
- E. Student can describe all the major steps of front derailleur placement and adjustment, and follow all the steps.



#### Demonstration Parts

(all removed from bike)

Front Derailleur

Shifter

Cable

Housing

Drive-side Cranks

#### Tools

Box Wrench set (8-10 mm)

Allen Wrenches

Adjustable Wrench

Flat-ended screwdriver

Phillips screwdriver

Fourth Hand Tool

Pliers

#### Other Materials

Grease

Penetrating Oil

Rags

Rubber Gloves

Ruler or straight edge

#### II. Materials Needed

**III. Setting** Workshop, with tool benches, bike repair stand and bike storage.

#### IV. Evaluation

- A. Teacher Observation During Work Session Rotate amongst the students as you work. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her/him come up with a solution?
- B. Oral Review at end of work session.
  - 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) **Systems:** Can the student say what components are part of the system on which we worked? How do they function as a whole?
  - 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- C. Written Evaluation How well can student narrate what she did that day on her time sheet?



## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### II. Process

**A. Goal** — What are we trying to get done when we replace and/or adjust a front derailleur? Have you ever ridden a bike where the chain wouldn't shift on the front chain rings? What can happen? How hard it is to pedal? The main purpose of the bike's front derailleur is to keep the chain from falling off on the front chain rings and to shift the chain from chain ring to chain ring in order to make the pedaling harder or easier (change the gear ratio) depending on what the rider desires.

A well done front derailleur adjustment or replacement makes sure that:

- the front derailleur is adjusted so that the chain does not fall off the chain rings when shifting the gears;
- the chain shifts smoothly from sprocket to sprocket without excessive grinding;
- the chain does not rub on the front derailleur cage except maybe slightly when in the small chainring in the front and small cog in the rear (a "crossover gear").

**B. Steps to Adjusting and Replacing Front Derailleurs** — Go over the names of each step, as a list.

Then describe each step to the students and have them each carry out that step on their bikes before you move the group onto the next step.

**1. Evaluate Condition** of as many parts as possible w/o disassembly.

- a) **Check Adjustment** Try shifting the front derailleur. How does it work? Does the chain rub a lot or come off the chain rings?
- b) **Cable and Housing** Is the exposed part of the cable rusty or frayed? Is your housing broken or rusting?
- c) **Shifter** Is your shifter pivoting smoothly?

**2. Decide if Front Derailleur Needs to be Replaced or Adjusted** If the derailleur seems to pivot smoothly, isn't bent, and the limit screws work then there shouldn't be any reason to replace the derailleur. It's always a good idea to replace a rusty cable or broken housing but if your front derailleur is in working order you can skip to step 8 (Adjustment). If you want to teach front derailleur installation anyhow, here are the steps to do it.

**3. Figuring Out What You've Got**

Before we can begin to take apart and replace our front derailleur cable system we've got to figure out just what we've got on our hands. Unlike hubs, rear derailleurs, and all rotational systems, many front derailleurs do not resemble each other in some key aspects. Front derailleurs are the most varied of any bike part in their technology and the most difficult to adjust. Much like the rear derailleur, in most cases, the front derailleur relies on a pivoting parallelogram. (Show students how a double pivot parallelogram allows the derailleur to move in a straight line across the chain rings rather than swinging in a circular motion if there was only one pivot point.)

**3. Figuring Out What You've Got** (continued)

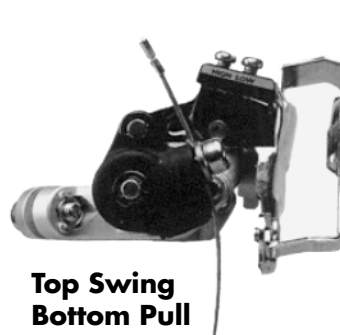
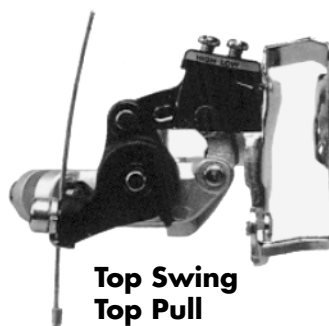
Most likely the kinds of derailleurs that you will encounter fall into these categories:

- 1) Top swing/Bottom pull
- 2) Bottom swing/ Top pull
- 3) Bottom swing/ Bottom pull
- 4) Bottom Swing/ Top pull (see diagram)

There are other types of front derailleurs out there, some based on a shaft inside a box and others that have single pivot swing arms encased in plastic. The principles covered here really only deal with the four main types of front derailleurs mentioned above.

The type of derailleur you've got depends on two factors: 1) The direction that the cable comes from to pull the derailleur, and 2) where the parallelogram is positioned in relation to the mounting of the derailleur itself. A top swing/bottom pull would have the parallelogram positioned above the mounting of the derailleur and the cable would be routed underneath the bottom bracket thus pulling the derailleur arm from the bottom.

Once you've determined what kind of derailleur you're dealing with (if you don't think you can remember, write it down) make sure that you've got a working replacement available before discarding your old one. Now you can start into the disassembly.

**Top Swing  
Bottom Pull****Traditional  
Bottom Pull****Top Swing  
Top Pull****Traditional  
Top Pull****4. Disassemble**

- a) Detach the derailleur cable by loosening the cable anchor bolt and let the cable hang loose
- b) Unscrew the derailleur cage bolt, also called the *entretois*. This is the bolt at the back of the derailleur cage that separates the two cage arms. Be careful to keep track of the spacer from the *entretois* as well as the bolt itself. If you don't unscrew this bolt, the chain will still be threaded through the derailleur cage even after you've taken the derailleur off the bike. You have the option of breaking the chain in order to get the front derailleur off but unless you're going to break the chain anyway, I don't recommend removing the derailleur in this way.
- c) Unscrew the derailleur mounting bolt
- d) Remove the derailleur from the seat tube.

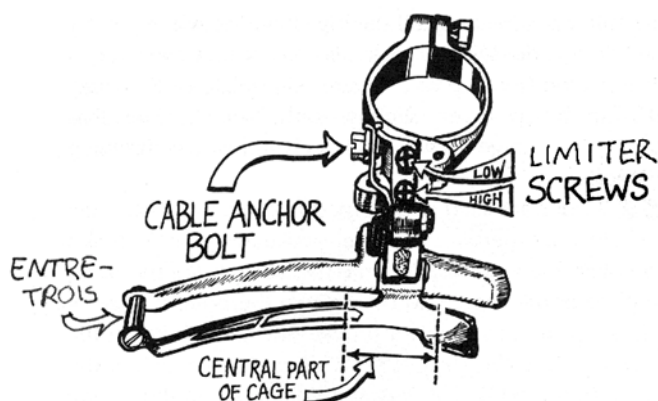


### 5. Clean and Inspect

Take some light oil or solvent and a tooth brush and scrub the derailleur. Since there are so many small parts, it's nice to have a compressor hose around to spray the derailleur once you've scrubbed it down. Inspect:

- a) Cables and housing- Rusty, frayed, or broken? Cable bent too much to go back through the housing?
- b) Derailleur cage- Is it bent?
- c) All bolts and nuts- Stripped?
- d) Limiter screws- Turn easily and are not stripped?

6. **Replace Parts** Parts are rarely replaced on derailleurs, since each model derailleur usually has slightly different dimensions. However, if you have a good supply of used parts around, you can often find a new limiter screw, *entretois*, or anchor bolt from a matching derailleur. The other parts of the system that do need replacing more frequently happily are made to a common standard: the cables, housing, and the cable and housing ends.



7. **Reassemble** This is just disassembly in reverse.

- a) Thread the chain through the derailleur cage and replace the cage bolt (*entretois*), making sure not to forget the spacer on the bolt.
  - b) Reattach the derailleur to the seat tube of the frame, making sure the central part of the cage clears the teeth of the largest chain ring by 1 mm (in the case of some Biopace chain rings the distance may vary so make sure to spin your chain rings to be sure) and
  - c) Make sure the outside edge of the cage is parallel to the chain when it is on large ring in the front and small cog in the back.
- d) With your shifter all the way down, i.e. as if the chain were in the smallest chain ring, attach the cable to the derailleur with the anchor bolt. As with the rear derailleur, there are many signs to tell you how your cable should be routed. The best bet is to remember how it was routed before you took it apart. But, if you've forgotten, here are some pointers.
- i. Look under the bottom bracket for your cable guide. There should be two places for a cable to move through. One should follow the line of the drive side chain stay. That's the guide for the rear derailleur cable. The other guide should curve up between the two chain stays. That's your front derailleur cable guide.
  - ii. If you don't see a cable guide underneath your bottom bracket, then most likely your cable goes above the bottom bracket. Look for a possible brazed-on or bolted-on cable guide that routes the cable just above the bottom bracket and up to the front derailleur.
  - iii. If you don't see a cable guide anywhere, then your cable is most likely routed through a short piece of housing that goes from a housing stop brazed onto the down tube close to the bottom bracket. This short piece of housing reaches, in a curve that touches the top of the bottom bracket, to the base of the front derailleur.
  - iv. If the derailleur is top pull then you won't have any cable guides at all.

**7. Reassemble - continued**

e) If you are using a new cable, you must pre-stretch it at this point. After attaching it with the cable anchor bolt, grab an exposed portion of the cable and pull it as hard as you can ten times.

\*\*\* Special note: In many cases there is a small metal tab that overlaps the spot where your cable mounting bolt is. Your cable does not go behind this tab. The cable goes over the tab and is pulled tight so that it comes perpendicular to the derailleur itself. This creates a higher leverage point and thus a better swing of the derailleur. The tab is there to keep the correct orientation of the anchor bolt.

**8. Adjust the front derailleur** Instructions for Index Shifting and a Triple Chainring

- a) Put chain on big chain ring and little cog and set the outer limiter screw so that the cage just clears the chain (1 mm or less).
- b) Put chain on little chain ring and big cog, set inner limiter screw so that cage just clears chain on the inside by 1 mm.
- c) Make sure that each barrel adjuster is screwed all that way down and then unscrewed 2-3 clicks. Loosen the cable anchor bolt, pull the cable through it until it is “hand-tight”, i.e. you pull the cable taught with your hand and screw the anchor bolt back down on it - keep the derailleur in the position you put it in in the previous step while you do this!
- d) Keeping chain on big cog in back, shift onto big chain ring in front. Then shift back down onto the center chainring. With a new cable (even though you have pre-stretched) adjust the cable tension so that the derailleur cage is just barely brushing the chain on the inside. With an old cable, adjust it so that the chain just barely clears the cage on the inside.

**9. Adjust the front derailleur** Instructions for Friction Shifting

Follow steps a) and b) of Section 8. above, and you should be done.

**10. Test Ride** All gear systems can behave differently when you are actually riding the bike than they do when you are testing them with the bike up in a workstand. (What are some of the possible reasons for this?) Put a screw driver that fits your limiter screws and the tool needed to loosen the anchor bolt in your pocket and go out for a brief ride.

- a) Put chain on big chain ring and little cog in back, and try shifting back and forth from the large to small chainring at least five times.
  - i. If the chain falls off on the inside, turn the inner limiter screw in 1/4 turn and try again.
  - ii. If the chain falls off on the outside, turn the outer limiter screw in 1/4 turn and try again.
  - iii. If the chain doesn't go smoothly up onto the largest chainring, you need to tighten the cable using the barrel adjuster (you *tighten* the cable by *unscrewing* the barrel adjuster). Unscrew it one turn and try again.
  - iv. If the chain won't go down onto the smallest chainring, it could be that the cable is too tight, or that the limiter screw is too far in? How can you tell which item to adjust? (You can see the bottom of the limiter screw and check whether it is bottomed out against the stop on the derailleur. If not, it is excess cable tension that is keeping the derailleur from moving the chain down onto the smallest chainring.



**10. Test Ride** - continued

- b) Put chain on big chain ring and *biggest* cog in back, and try shifting back and forth from the large to small chainring at least five times. Now the chain is pulling at a slightly different angle, and you need to repeat the adjustments as above.

All done!

**III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get the students to touch each of these parts on their bikes & say the name.

**Main Part (derailleur)**

Parallelogram  
Cage  
Mounting bracket

**Main Part (shifter)**

Lever  
Cables  
Housing  
Cable guide

**Necessary Tools**

Box wrenches  
Screw driver  
Pliers  
Fourth hand  
Allen Wrenches

**Other Materials**

Light oil  
Grease  
Pen

**Math & Physics Words**

Parallelogram  
Friction  
Leverage  
Perpendicular

**IV. System Understanding** Try different ways of phrasing this question.

What components are part of the front derailleur system? How do they interact/affect each other/work together? How do they function as a whole? Why can the derailleur system be described as a “cable tension, spring release” system? When you pull on the shift lever, the lever pulls on the cable and moves the derailleur up and out away from the frame. Can you push with a cable (try it with a cable extended between two students!)? When you release the tension on the cable by moving the shifter back to its original position, what pushes the derailleur back down?

**V. Problem Solving/Diagnosis**

1. What does it mean if you get an adjustment that throws the chain off the biggest chainring? or the smallest?
2. How can you tell if you need a new derailleur?
3. Why might your front derailleur work fine in the stand but not work on the road?
4. What could cause your front derailleur to quickly lose it's adjustment?
5. What other problem solving did we do?

**VI. Review****VII. Clean Up****VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

<b>Tire and Wheel (Pneumatic Suspension) Systems .....</b>	<b>2</b>
<b>Part One - Preparation .....</b>	<b>2</b>
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2
<b>Part Two - Activity Instructions .....</b>	<b>3</b>
I. Tool Check! .....	3
II. Language Skills .....	3
III. System Understanding .....	3
IV. Process .....	3
Steps to Fix a Flat .....	4
V. Problem Solving/Diagnosis .....	5
VI. Review .....	5

## Part One - Preparation

- A. Student can identify a tire or tube in need of repair.
- B. Student can name the parts of the tire, tube and wheel and the tools used on them.
- C. Student becomes more familiar with the math concepts of circumference and diameter.
- D. Student becomes more familiar with the physics concepts of friction, leverage and force.
- E. Student can describe all the major steps of flat fixing and follow all the steps.

Cut in half tire
Tube
Wheel without tire and tube

Tire Irons  
Patch Kit - includes Glue, Patches,  
and Sand Paper

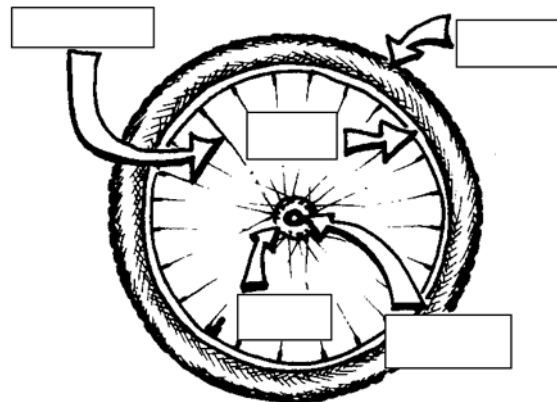
Rags  
Rubber Gloves  
Ball Point Pen

## IV. Evaluation

B. Oral Review at end of work session.

- 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
- 2) **Systems:** Can the student say what components are part of the system on which they worked? How do these components function as a whole?
- 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?

**D. Test** Can student identify the parts in this diagram?





## Part Two - Activity Instructions

**I. Tool Check!** Instructors enter tool area with students and confirm as a group that all tools are present.

## II. Language Skills

Over the course of the lesson we should introduce all of the terms below. At the end of the session it is often helpful to get each young person to touch each of these parts on his/her bike & say the name.

### Tire

Tread  
Sidewall  
Bead  
Threads (embedded in the tire)

### Tube

Valve  
Valve Stem  
Schraeder( or American) Valve (AV)  
Presta (or French) Valve (FV)  
Valve Cap

### Rim

Rim Edges (hook bead)  
Valve Hole  
Bead Seat Diameter  
Rim Strip  
Spoke ends (spoke nipple heads)

### Necessary Tools

Pressure Gauge  
Tire Irons (tire levers)  
Pump or Compressor  
Sandpaper  
Valve Core Remover  
Wrench (adjustable or fixed)

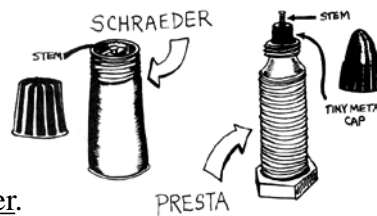
### Other Materials

Patches  
Glue  
Bucket and Water  
Pen or Chalk

### Math Words

Area (contact patch)  
Circumference  
Diameter

**Note:** To fix a flat you also deal with the rotational system in a hub, so there is more technical vocabulary that comes into play, Most importantly: axle, axle nut, axle washer, quick release skewer. Also: drop-outs, derailleur hanger.



**valve types**

## III. System Understanding

Try these (and other!) different ways of phrasing this question:

“What components are part of the pneumatic suspension system?” “How do they interact/affect each other/work together?” “How do they function as a whole?”

## IV. Process

**A. Goal** — What are we trying to get done when we fix a flat tire? The obvious answer is get our bike rideable again (by refilling the pneumatic suspension system!). Has anyone ever ridden a bike with no tire on its rim? What would happen if you rode that way for a while? to you? to the bike? A well done flat fixing job also makes sure that your bike:

- has nothing that is about to break (tires not frayed, or split, or bald)
- tires adequately inflated (to protect rims and prevent “snake-bite” flats)
- isn’t going to go flat again soon due to slow leak or bad valve
- has the best tire installed for the type of riding you’ll be doing



**B. Steps to Fix a Flat** — There are several steps to fixing a flat. Go over the name of each step, as a list. Then describe each step to the students and have them each carry out that step on their bike before you move the group onto the next step.

1. Evaluate Condition of existing parts, decide what to replace (examine tire before removing wheel from bike)

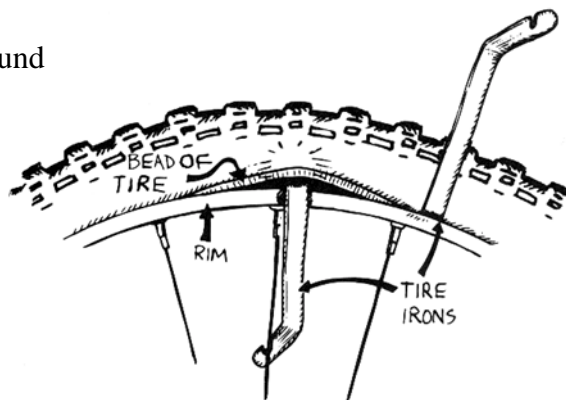
- Tire condition holes in sidewall? bald? cracks?
- Any obvious causes of flat? nails, tacks, etc.
- Tube condition valve leaks? valve stem straight? **spit test**
- what happened when the tire went flat -was it all of a sudden? slowly? how does this information give us clues about the cause of the flat?

2. Remove Wheel

- Tool concepts fixed vs. adjustable wrenches, vise grips/pliers (for round surfaces) vs. wrenches (for flat surfaces - point out parallel jaws)
- Work habits look carefully at order of components before taking apart.  
Where are the axle washers? With Bolt On wheels, put axle nuts back on axle if you have to take them all the way off (so you won't lose them!)

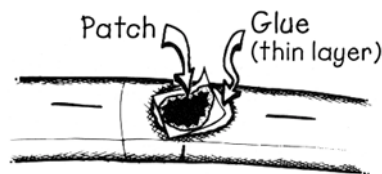
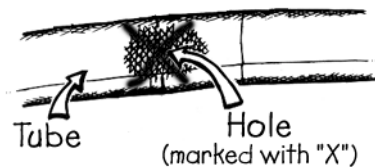
3. Remove Tire and Tube from Rim

- Let out remaining air
- Take one side of tire (bead) off the rim all the way around
  - proper use of tire iron
  - start opposite valve, end at valve (how?)
- Remove second side (show "upside-down U" move)
- Keep tire, tube and rim all together (in the same orientation with respect to each other) to help in your detective work locating the hole and cause!



4. Find and Patch Hole

- Blow up tube, don't be afraid to make it 1½" to 2" in diameter
  - listen for air, feel with cheek or hand
  - use water to spot the leak if you can't hear or feel it
- Mark hole (a big "X" marks the spot!)
- Inspect rim and tire for causes at the spots that were next to this hole
- Patch hole
  - clean and sand surface well, flatten seams/ridges
  - not too much glue, let it dry first

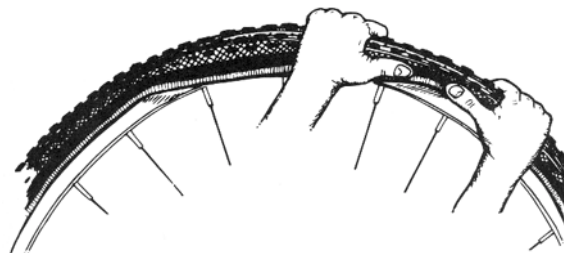


**4. Find and Patch Hole** - continued

- e) Fill it up (not so big this time!) and look for a 2nd hole
  - Why might a 2nd hole show up now that we didn't see/hear before?
- f) Inspect the whole tire and rim carefully for rough edges, sharp things, holes, etc.

**5. Remount Tire and Tube on Rim** — No tools!! It's technique, not strength.**6. Inflate** slowly, and check that tire is seated in rim**7. Remount Wheel in Frame**

- a) make sure it's centered (look at frame, not brake pads!)
- b) make sure it's tightened (What could happen if your wheel falls off?)

**V. Problem Solving/Diagnosis**

1. How can you tell if the hole was caused by a problem in the rim or by something that came through the tire?
2. What can you figure out from the information the bike rider gives you about how the tire went flat?
3. What other problem solving did we do?

**VI. Review****VII. Clean Up****VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

<b>Rotational Systems —</b>	
<b>Bottom Bracket Overhaul &amp; Adjustment .....</b>	<b>2</b>
<b>Part One - Preparation .....</b>	<b>2</b>
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting: .....	2
IV. Evaluation .....	2
<b>Part Two - Activity Instructions .....</b>	<b>3</b>
I. Tool Check! .....	3
II. Process .....	3
Steps to Overhaul a One-Piece Bottom Bracket (Ashtabula style) .....	3
Steps to Overhaul a Three-Piece Bottom Bracket .....	5
III. Language Skills .....	7
IV. System Understanding .....	7
V. Problem Solving/Diagnosis .....	7
VI. Review .....	7
<b>Alternate Text for Three-Piece Crank Adjustment .....</b>	<b>8</b>





## Rotational Systems — Bottom Bracket Overhaul & Adjustment

### Part One - Preparation

#### I. Objectives

- A. Reinforce basic concepts of correct tool use.
- B. Introduce rotational systems and bearing adjustments. Students should be able to describe what a good bearing adjustment is and why.
- C. Reinforce the math concepts of parallel and perpendicular lines. Introduce the physics concepts of force and friction.

#### II. Materials Needed

##### Demonstration Parts

(All removed from bike)  
One piece crank w/chainring, cups, and rest of BB set  
BB Spindle & Cottered crank set  
BB Spindle & Cotterless crank set  
BB cup set w/ bearings in retainer, on a spindle  
Pitted cups, spindle, bearings

##### Tools

Hook spanner/Lockring wrench  
Fixed cup remover  
Hammer  
12" Adj. Wrench  
Pedal Wrench  
Bottom Bracket/Headset Press  
Pin Tool  
Flat End Punch

##### Other Materials

Grease  
Penetrating Oil  
Rags  
Rubber Gloves  
Locktite

**III. Setting:** Workshop, with tool benches, bike repair stand and bike storage.

#### IV. Evaluation

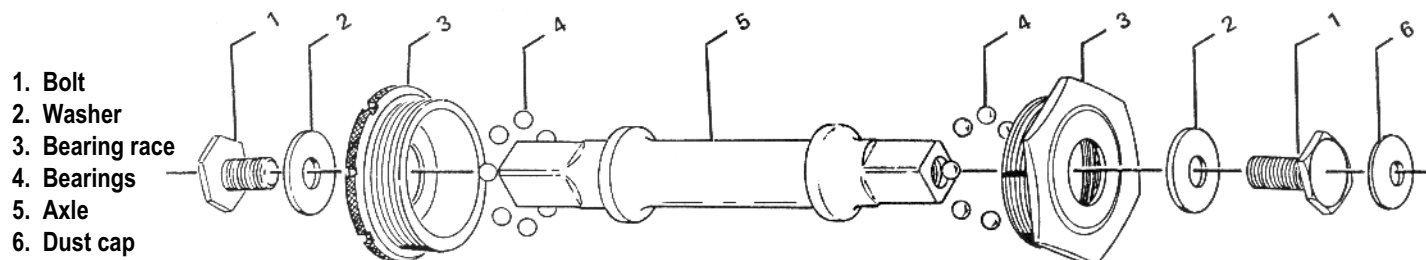
A. Teacher Observation During Work Session

B. Oral Review at end of work session.

- 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
- 2) **Systems:** Can the student say what components are part of the system on which they worked? How do the components function as a whole?
- 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?

C. Written Evaluation How well can student narrate what she did that day on her time sheet?

D. Test Make copies of the diagram below and have students fill in the names of the parts.





## Part Two - Activity Instructions

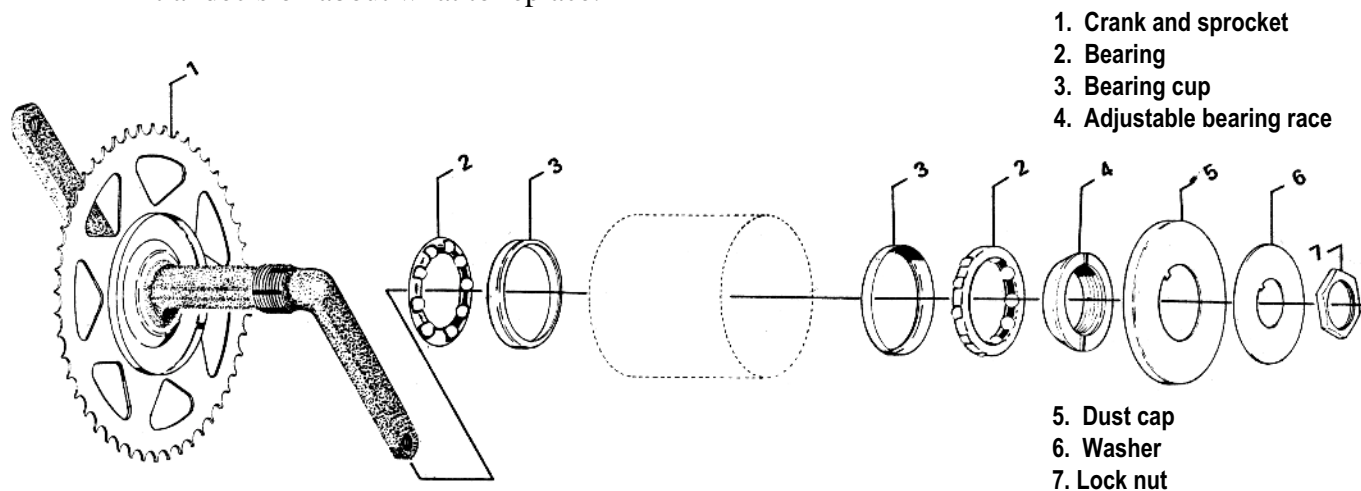
**I. Tool Check!** Instructors enter tool area with students and confirm as a group that all tools are present.

### II. Process

- A. Goal** — The main purposes of each of the bike's rotational systems are: 1) to allow rotation (turning) without a lot of friction and with no side to side play, and, 2) to bear weight. A well done bottom bracket job also makes sure that:
- your bike has nothing in the bottom bracket/crank system that is about to break (crank arm or pedal about to fall off, etc.)
  - the BB set isn't going to go out of adjustment again soon (due to cup/cone not being locked in place, or due to pressed-in cups collapsing inwards in a one piece crank set)

**B. Steps to Overhaul a One-Piece Bottom Bracket (Ashtabula style)** — Go over the name of each step, as a list. Then describe each step to the students and have them each carry out that step on their bike before you move the group onto the next step.

- 1. Evaluate Condition** of existing parts before disassembling. Check the adjustment. Does everything fit together well? How is the chain line? Are the chainrings, pedals or the crank arms bent? Make an initial decision about what to replace.



### 2. Disassemble

- Remove the Left Pedal (unscrews clockwise! - it's a "left-hand thread")
- Unlock the lock nut from the cone on the Left side (the adjustable side) - this is also a "left-hand thread," unscrew both all the way, taking them off the crank arm, along with whatever washer is on that side.
- Stack Up All Parts in the order in which you take them off!
- Pull out the Left Bearing Retainer
- Pull out the Crank Arm and the right bearing retainer

**B. Steps to Overhaul a One-Piece Bottom Bracket** - continued

3. **Clean and Inspect** all the bearing surfaces and threads, looking for pits or scratches on the cones, bearings or cups. Remove cups if they are loose or look like they may be getting pushed inwards, or if they need to be replaced.
4. **Replace Parts** as necessary (and possible! if you don't have a replacement for a pitted cone or cup, go ahead and reassemble with lots of new clean grease. You'll get a better bearing adjustment than you started out with, though not perfect). If the cups are starting to collapse inwards (compare profile to a new cup), you have to replace them.
5. **Reassemble** — this is just disassembly in reverse.
  - a) Reinstall cups if you removed them, using press or a hammer on the flat handle of a headset wrench placed across cup.
  - b) Grease the cups putting a good thick layer in the back of each.
  - c) Slide Right Bearing Retainer onto Crank Arm, up against Right Cone Check which side of the retainer faces cone!
  - d) Slide crank arm back through BB
  - e) Reinstall Left bearing retainer, adjustable cone, washer and locknut finger tight.
  - f) Reinstall the Left Pedal (screws in counterclockwise). Ready to adjust!
6. **Adjust the bearings.**
  - a) Find Out How Good an Adjustment You Can Get With fingers or tools, screw the adjustable cone in and out on the crank until you find a spot where the bearing adjustment is both not too loose and not too tight (how do you check?)
  - b) Get the Adjustable Cone Locked in the Correct Position
    - starting at the “best adjustment position” you found for the cone in the previous step, carefully loosen the cone (turning it clockwise!) 45° (7 minutes, thinking of a clock)
    - hold the cone in place, not letting it or the crank arm rotate (what tool do you need?), and tighten down the lock nut against the cone. Test the adjustment for play and grinding.
    - If it's too loose, hold the cone completely still while you unscrew the lock nut. Screw in the cone just 5° (1 minute) counterclockwise. Hold it completely still while you tighten the lock nut down against it again. Test the adjustment. If it's still too loose, repeat this step. If it's too tight, hold the cone still, loosen the lock nut and carefully unscrew the cone 1/2 of the distance you just tightened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the cone still and check the adjustment again.
    - If it's too tight, hold the cone completely still while you unscrew the lock nut. Unscrew the cone just 5° (1 minute) clockwise. Hold it completely still while you tighten the lock nut down against it again. Test the adjustment. If it's still too tight, repeat this step. If it's too loose, hold the cone still, loosen the lock nut and carefully screw in the cone (counterclockwise) 1/2 of the distance you just loosened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the cone still and check the adjustment again.

**6. Adjust the bearings.** (continued)

- The most important ideas here are:

◊ Don't lose your point of reference by letting the cone move as you loosen back up the lock nut, because you'll have to start all over again.

◊ Tiny rotations of the cone make a big difference in the pressure on the bearings. How far are you moving the cone along the axle if you turn it, say, 1/4 turn (90° or 15 minutes)? Hint: How many threads per inch (tpi) are there on the crank?

**C. Steps to Overhaul a Three-Piece Bottom Bracket** — Go over the name of each step, as a list. Then describe each step to the students and have them each carry out that step on their bike before you move the group onto the next step.

1. **Evaluate Condition** of existing parts before disassembling. Does everything fit together well. How is the chain line? How much clearance is there between the chainstays and the crank arms? Are the chainrings, pedals or the crank arms bent? Decide if any of these external parts need to be replaced. Test the adjustment.

**2. Disassemble**

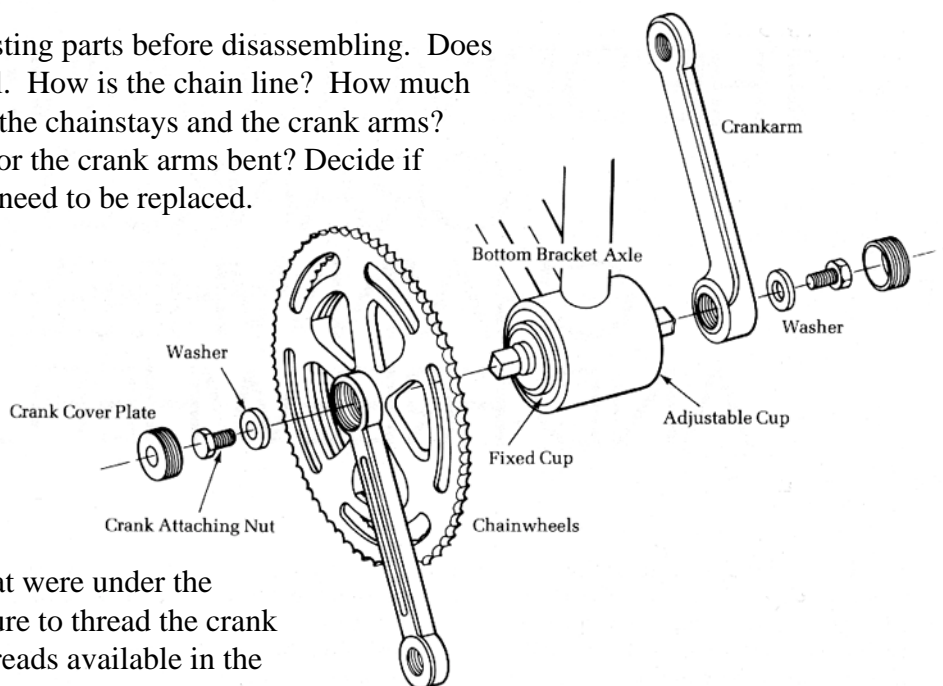
- a) Remove the crank arms

with the cotterless crank puller or the cotter pin press

- Cotterless: start w/left crank, it costs less if you ruin it! Be sure to remove any washers that were under the crank bolt or nut. Be sure to thread the crank puller in until all the threads available in the crank are engaged in the puller.
- Cottered: always squirt penetrating oil down the cotter pin and remove the nut before you attempt to press the pin out.

- b) Test the adjustment again with the crank arms off. Notice how the reduced leverage makes the bearings feel tighter and how it is easier to feel roughness.
- c) Unlock the lock ring from the adjustable cup on the Left side, unscrew the adj. cup, taking it out of the BB shell, along with the bearings inside it (they may be loose or in a retainer).
- d) Pull out the Spindle and the Bearings from the fixed cup. If one end of the spindle is longer than the other, notice which side it was facing.
- e) Stack up All Parts in the order in which you take them off!

3. **Clean and Inspect** all the bearing surfaces and threads, looking for pits or scratches on the cones, bearings or cups. Inspect the fixed cup with a flashlight and a ball point pen. Remove it only if it will be replaced.



**C. Steps to Overhaul a Three-Piece Bottom Bracket (continued)**

**4. Replace Parts** as necessary (and possible! if you don't have a replacement for a pitted spindle or cup, go ahead and reassemble with lots of new clean grease — you'll get a better bearing adjustment than you started out with, though not perfect).

**5. Reassemble** this is just disassembly in reverse.

a) Make sure the Fixed Cup is Tight, using the fixed cup remover if necessary.

b) Grease the cups putting a good thick layer inside each.

c) Stick the Bearings back in the Cups

- For bearings in retainers, check which side faces cup!
- If bearings are loose, there should be 11 of them (1/4" balls)

**C. Steps to Overhaul a Three-Piece Bottom Bracket - continued**

d) Stick in the Spindle, making sure that if one end is longer, it faces in the right direction.

e) Reinstall Adjustable Cup, and Lockring. Ready to adjust!

**6. Adjust the bearings.**

a) Find Out How Good an Adjustment You Can Get

- Reinstall the right crank so that you can use it as a lever when you check the adjustment. Secure it well.
- With fingers or tools, move cup in and out until you find a spot where the adjustment is both not too loose and not too tight (how do you check?)

b) Get the Adjustable Cup Locked in the Correct Position

- This process is the same as for a one piece crank, with one exception: the action of tightening the lockring against the frame forces the cup out rather than further in. Therefore the bearing adjustment gets looser as you lock down the lockring.
  - So, starting at the "best adjustment position" you found in the previous step, carefully tighten the cup (turning it clockwise) 20° (about 3 minutes, thinking of a clock). Then hold the cup still while tightening down the lockring.
- Check the adjustment... if too loose or too tight, proceed as with the one-piece crank.



### **III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get each student to touch each of these parts on his/her bike & say the name.

#### **Crank Set**

Crank Arm, L & R  
Chainrings & Spider  
Crank Nuts/Bolts  
Cotter Pins  
Cottered/Cotterless  
Pedals  
Bottom Bracket Shell (frame part)

#### **Bottom Bracket Set**

(Three Piece Crank Set)  
Fixed Cup  
Adjustable Cup  
Lockring  
Spindle  
Ball Bearings  
Dust Seal

#### **Bottom Bracket Set**

(One Piece Crank Set)  
Fixed & Adj. Cones  
Lockwasher  
Locknut  
Spacer  
Ball Bearings  
Bearing Retainers  
Cups (pressed in)

#### **Specialty Tools**

Fixed Cup Remover  
Pin Tool  
Lockring wrench  
BB/Headset Cup Press  
Pedal Wrench

#### **Other Materials**

Grease  
Rags  
Penetrating Oil

#### **Common Tools**

Hammer  
Flat End Punch  
12" Adj. Wrench

#### **Math Words**

Diameter  
Length  
tpi- threads per inch  
millimeters (mm)  
Clockwise  
Counter Clockwise  
Perpendicular (90°)  
Parallel

**Note:** The Bottom Bracket Set and the Crank Set are both part of the larger system called the Drive Train. Another part of the drive chain that you'll probably deal with in this lesson is the chain.  
Other words: Left-Hand Threads, Right-Hand Threads.

### **IV. System Understanding** Try different ways of phrasing this question.

What components are part of the Bottom Bracket system? How do they interact/affect each other/work together? How do they function as a whole?

What is the bigger system the Bottom Bracket is a part of (the Drive Train)?

### **V. Problem Solving/Diagnosis**

- A. On a three piece crank, what are three possible causes of play felt when you try to rock the crank arm from side to side? How could you figure out which is the actual cause?
- B. If you adjust a one-piece crank perfectly, making sure to secure the lock nut well on the adjustable side, and then the adjustment is loose again after only a little riding, what are some possible causes? How could you figure out which is the actual cause?
- C. What other problem solving did we do?

### **VI. Review**

### **VII. Clean Up**

### **VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



## Alternate Text for Three-Piece Crank Adjustment

(Each step intended where it says, “proceed as with the one-piece crank” is detailed here.)

### 6. Adjust the bearings.

#### a) Find Out How Good an Adjustment You Can Get

- Reinstall the right crank so that you can use it as a lever when you check the adjustment. Secure it well.
- With fingers or tools, move cup in and out until you find a spot where the adjustment is both not too loose and not too tight (how do you check?)

#### b) Get the Adjustable Cup Locked in the Correct Position

- starting at the “best adjustment position” you found for the cup in the previous step, carefully tighten the cup (turning it clockwise) 20° (about 3 minutes, thinking of a clock)
- hold the cup in place, not letting it rotate, and tighten down the lockring against the frame
- Test the adjustment for play and grinding
- If it's too loose, hold the cup completely still while you unscrew the lockring. Screw in the cup just 5° (1 minute) clockwise. Hold the cup completely still while you tighten the lockring back down against the frame. Test the adjustment. If it's still too loose, repeat this step. If it's too tight, hold the cup still, loosen the lockring and carefully unscrew the cup 1/2 of the distance you just tightened it (about 2 1/2° or 1/2 minute). Tighten down the lockring while holding the cup still and check the adjustment again.
- If it's too tight, hold the cup completely still while you unscrew the lockring. Unscrew in the cup just 5° (1 minute) counterclockwise. Hold it completely still while you tighten the lock nut down against it again. Test the adjustment. If it's still too tight, repeat this step. If it's too loose, hold the cone still, loosen the lock nut and carefully screw in the cup (clockwise) 1/2 of the distance you just loosened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the cone still and check the adjustment again.
- The most important ideas here are:
  - ◊ Don't lose your point of reference by letting the cone move as you loosen back up the lock nut, because you'll have to start all over again.
  - ◊ Tiny rotations of the cone make a big difference in the pressure on the bearings. How far are you moving the cone up along the axle if you turn it, say, 1/4 turn (90° or 15 minutes)? Hint: How many threads per inch (tpi) are there on the crank.

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# Contents

<b>Basic Tools .....</b>	<b>2</b>
<b>Part One - Preparation .....</b>	<b>2</b>
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2
<b>Tool Identification Test .....</b>	<b>3</b>
<b>Part Two - Activity Instructions .....</b>	<b>4</b>
I. Tool Check! .....	4
II. Process .....	4
The Great Leverage Test .....	4
How to Use the Adjustable Wrench .....	5
III. Language Skills .....	5
IV. Systems Understanding .....	5
VI. Review .....	5





## Basic Tools

### Part One - Preparation

#### I. Objectives

- A. Student can identify basic tools (both name and function) used in bike repair.
- B. Student can use each tool in a proper and effective manner.
- C. Student is aware of which tools are required for which jobs.
- D. Student becomes more familiar with the physics concepts of leverage and torque.
- E. Student knows where all tools are placed when finished with them.

#### II. Materials Needed

##### Demonstration Parts

- A 2x4 at least five feet in length
- Angle iron to work as fulcrum for 2x4
- Large adjustable wrench
- Small adjustable wrench
- Bicycle Wheel, Not Mounted

##### Tools

- Adjustable Wrenches
- Fixed Wrenches
- “T” and “Y” Wrenches
- Cone and Brakes Wrenches
- Hammer
- Allen Keys
- Screw Drivers

##### Other Materials

- Chalkboard & Chalk
- Rags



**Vise grips**

#### III. Setting There are two possible settings.

- A. Workshop, with tool benches, bike repair stand and bike storage.
- B. Outdoor, Non-Traffic Practice Area — playground, empty parking lot, wide sidewalk, etc.

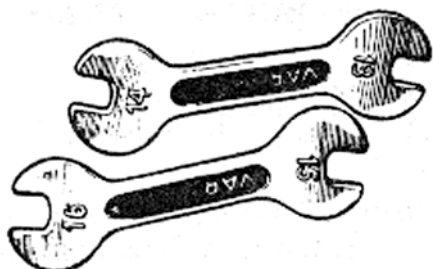
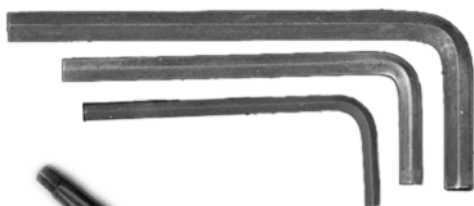
#### IV. Evaluation

- A. Teacher Observation During Work Session Rotate amongst the students you are working with. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to visually confirm good contact between tool and part. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her come up with a solution?
- B. Oral Review at end of work session.
  - 1) **Language:** How many of the basic tools and specialty tools can students identify? Passively? Actively? Can each student identify the proper function of each tool?
- C. Written Evaluation How well can student narrate what she did that day on her time sheet?
- D. Test Tool Identification Test. See the basic test on the next page, with pictures of each of the basic tools and a list of the names on the edge of the paper. The students should be able to draw lines from the name of the tool to the correct picture.



## Tool Identification Test

Connect the tool pictures on the left with their names on the right



**Allen Key**

**Cone Wrench**

**Screwdriver**

**Adjustable Wrench**

**Y-Wrench**

**Hammer**

**Pliers**



## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### II. Process

**A. Goal** — To learn to “use the right tool for the right job.” What does this mean? Have you ever used the wrong tool for the job? What happened? How does leverage change when your lever gets longer?

The right tools for the right job should fulfill these requirements:

- The surface of the tool fits not too tight and not too loose inside or around the object you are trying to loosen or to tighten. Why is a good fit important?
- You have enough leverage to complete the job without straining too much. (Sometimes you may have to strain but that can be fun too!!)



**Needlenose Pliers**

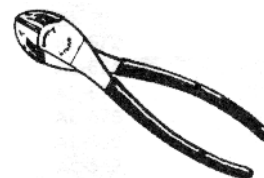
**B. The Great Leverage Test** — This little test is basic but fun for the students because it’s really hands on.

#### **1. The Parts of a Lever**

- a) The Lever (the 2x4)
  - b) The fulcrum (the piece of angle iron)
2. Place the 2x4 over the piece of angle iron to make a small version of a see saw. Be sure to put the angle iron in the middle of the 2x4
  3. Test the abilities of a Lever. If you can, try to find two students who are very different in size and weight. Have the lighter of the two stand on one end of the 2x4. Then have the heavier student slowly stand on the other end of the 2x4 and watch as the smaller of the two is lifted into the air. This is what everybody expects but is still fun to watch and take part in. Now its time to figure out how to make it so that the lighter of the two students can use his or her own weight to lift the heavier student into the air. Make sure that you allow that all the students come up with the answer. First try to figure out how to balance the two students. Draw a line where this point on the lever is. Then figure out the point at which it becomes easy for the lighter of the two the lift the other into the air. Now relate this back to using certain tools that have a longer handle verses a shorter handle. Is it going to be easier to turn a bolt with a wrench that has a long handle or a short one? Why?



**Channel-Locks w/  
Parallel Jaws**



**Cable Cutters**

**C. How to Use the Adjustable Wrench**

1. Find a good sized nut or bolt head. If you don't have a lot of hardware around, an axle-nut on a wheel will do just fine.
2. Pull out an adjustable wrench and show the students how the jaw of the tool adjusts.

Note: The adjustment of the wrench uses a simple tool — the incline plane!!

3. Leaving the wrench open, place the jaws around the bolt head/nut and slowly begin to wind the jaws closed.
4. Leaving the jaws of the wrench slightly open (2 or 3 millimeters) around the nut bring it to the attention of the students what will happen if you attempt to loosen or tighten the nut without the jaws being tight (i.e. stripping/rounding off the corners). What happens if they tighten the jaws against two corners of a nut instead of against the flats?
5. Tighten down the jaws of the wrench until both the adjustable side and the fixed side sit firmly and parallel to the flats/sides of the nut. Voila! You have now properly fitted your adjustable wrench. Practice taking it off and putting it back on. Demonstrate jiggling the wrench a bit as you screw down the adjustable jaw with the thumb screw.

**III. Language Skills**

Over the course of this lesson we have introduced a whole set of new tools and science terms. At the end of the session it is often helpful to get each kid to put their finger on each of these tools again and say the name.

**IV. Systems Understanding** Try different ways of phrasing these questions.

What does it mean to have the right tool for the right job? How do we evaluate which tool needs to be used in which situation. What can go wrong if we use the wrong tool?

**V. Problem Solving/Diagnosis**

Put a bicycle on a stand and hold up each tool. See if the students can pick out spots where that tool will be used. Have each student show what would be the best way to use at least one tool in particular. Once they all have had a chance to give an answer and use a tool on the bike, pat yourself on the back and call it a day.

**VI. Review****VII. Clean Up****VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

## **Rotational Systems — Hub Overhaul and Adjustment ..... 2**

### **Part One - Preparation ..... 2**

I. Objectives .....	2
I. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2

### **Part Two - Activity Instructions ..... 3**

I. Tool Check! .....	3
II. Process .....	3
Steps to Overhauling and Adjusting a Hub .....	3
Evaluate Condition .....	3
Disassemble .....	4
III. Language Skills .....	6
IV. System Understanding .....	6
V. Problem Solving/Diagnosis .....	6
VI. Review .....	6



# Rotational Systems — Hub Overhaul and Adjustment

## Part One - Preparation

### I. Objectives

- Student can identify a hub in need of adjustment.
- Student can name the parts of the hub system and the tools used on it.
- Student becomes more familiar with the math concepts of perpendicular and parallel.
- Student becomes more familiar with the physics concepts of friction and force.
- Student can describe all the major steps of hub overhaul, and follow all the steps.

### I. Materials Needed

#### Demonstration Parts

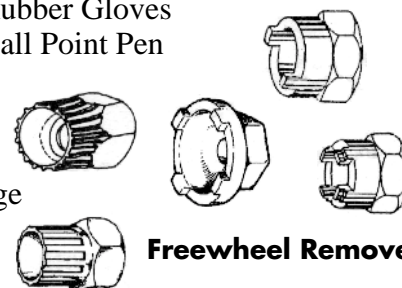
Hub, assembled w/guts but no dust caps  
Axle w/cone and lock nut on either end, one side locked  
Empty hub  
Front & rear hubs w/o wheel  
Pitted hub, cone, bearings

#### Tools

15 & 17 mm Combo Wrench (optional)  
Adjustable Wrenches  
Cone Wrenches  
Flat ended screwdriver  
Freewheel/cassette Remover  
Bench Vise  
Chain Whip

#### Other Materials

Grease  
Penetrating Oil  
Rags  
Rubber Gloves  
Ball Point Pen

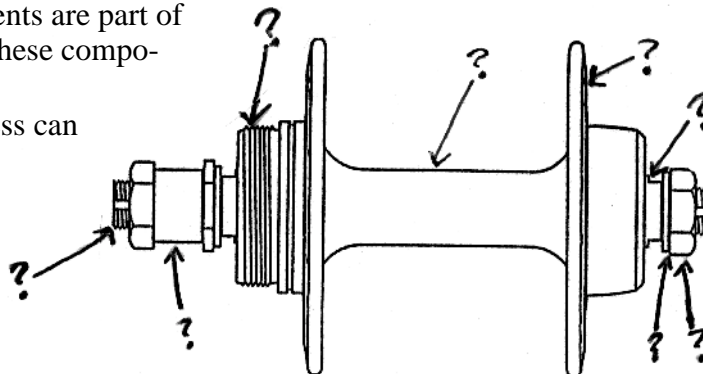


**Freewheel Removers**

**III. Setting:** Workshop, with tool benches, bike repair stand and bike storage

### IV. Evaluation

- Teacher Observation During Work Session** Rotate amongst the students you are working with. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her come up with a solution?
- Oral Review at end of work session.**
  - Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - Systems:** Can the student say what components are part of the system on which they worked? How do these components function as a whole?
  - Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- Written Evaluation** How well can student narrate what she did that day on her time sheet?
- Test** Can student identify the parts in this diagram? Is this a front hub or a rear hub?





## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### II. Process

**A. Goal** — What are we trying to get done when we adjust or overhaul a hub? Have you ever ridden a bike where the wheel was knocking from side to side? What can happen? How does that side-to-side play affect your brakes? How hard it is to pedal? The main purposes of each of the bike's rotational systems are: 1) to allow rotation (turning) without a lot of friction, and, 2) to bear weight. A well done hub adjustment or overhaul makes sure that:

- the hub is adjusted so that there is no play (when the wheel is firmly attached to the bike), **and hardly any friction** (not too loose, not too tight). In order to get no play, the axle must be perpendicular to the plane of the cups. Why?
- the hub isn't going to go out of adjustment again soon (due to cone not being locked in place, or the parts being pitted or cracked already)
- the bearings are well lubricated, both to reduce friction and to prevent rust (why don't we want rust?)

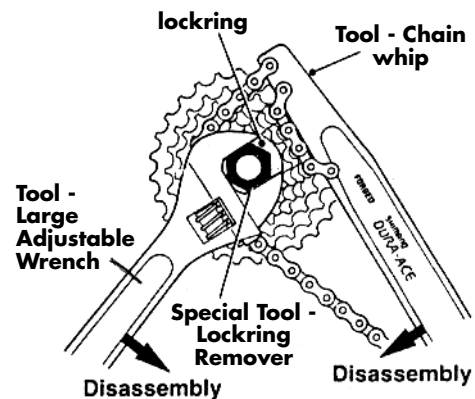
**B. Steps to Overhauling and Adjusting a Hub** — Go over the names of each step, as a list. Then describe each step to the students and have them each carry out that step on their bikes before you move the group onto the next step.

**1. Evaluate Condition** of as many parts as possible without disassembling.

- a) Check Adjustment first on bike, by moving wheel; then off the bike, by moving axle. Is there both grinding and play? Any idea what this might mean about the parts inside? (Come back to this idea when doing the adjustments.)
- b) Axle Straight? rotate it while it's still in the hub, does the end seem to wobble around, or does it stay in one place?
- c) Axle Threads OK? are they mushed, or flattened?
- d) Dust Caps flat, fitting well into hub?

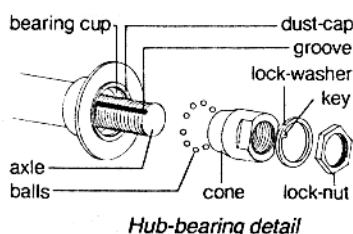
**2. For Rear Wheels, Remove the FreeWheel** and remove the Cassette if it's the type where you can't get to the slots in the cone with the cassette on.

**3. Decide if Hub Needs to be Overhauled** If you can get a good adjustment (no play and no grinding), then the bearings and the bearing surfaces on the cones and in the cups inside are all in good shape and well lubricated. If your goal is just to get the bike ready, skip to step 8 and try an adjustment. If you want to teach the overhaul anyway, go on to step 4.



**Removing a Cassette.**





#### 4. Disassemble

- Unlock the lock nut from the cone on one end of the axle, unscrew them all the way, taking them off the axle.
- Stack Up All Parts in the order in which you take them off!
- Pull out the Axle, then remove the dust caps gently with a flat end screw-driver  
(don't take them out of cassette hubs or 1963 Normandy Competition hubs).
- Pull out the Bearings

#### 5. Clean and Inspect all the bearing surfaces and threads — rub them with a rag.

- Pits or scratches on the cones, bearings or cups?
- Axle Straight ? roll it on flat table
- Threads mushed?

#### 6. Replace Parts as necessary (and possible! if you don't have a replacement for a pitted cone, go ahead and reassemble with lots of new clean grease. You'll get a better bearing adjustment than you started out with, though not perfect).

#### 7. Reassemble this is just disassembly in reverse.

- Grease the cups putting a good thick layer in the back of each.
- Stick in the ball bearings
  - Rear Hubs: nine 1/4" balls on each side
  - Front Hubs: ten 3/16" balls on each side
- Install Dust caps if you took them out, tap them with a hammer against the flat of a cone wrench
- Stick the Axle through the Hub Which end goes on which side? Screw the cone, any spacer, washer and lock nut back on the other end. You are ready to adjust!



**Bearings come in many  
Different Sizes**

#### 8. Adjust the bearings.

- Make the Right End of the Axle the Fixed Side (R. cone is dragged on by bearings in a direction that makes it want to screw down in tighter on the bearings.) Start w/wheel vertical on bench or floor.
  - Cone Wrench in left hand, in slots on cone, horizontal
  - Fixed or Adjustable Wrench in Right Hand on lock nut, horizontal, opposite the cone wrench
  - Tighten Them Against Each Other —lean down on the wrenches. You'll be turning the cone counterclockwise, unscrewing it, and at the same time, turning the lock nut clockwise, tightening it against the cone.
- Hold the Axle still, using the Fixed Side as a handle.
  - put the lock nut of the fixed side in the bench vise, or get a friend to hold a wrench on the lock nut, bracing her hand against the spokes.
- Find the Right Position for the Cone on the Adjustable Side, and Lock it in Place.
  - with two fingers lightly rotating the cone wrench clockwise, turn it until you feel it just hit the bearings, then back the cone off 90° (15 min. on clock)
  - test for play by seeing if wheel rocks against axle. Move the cone another 5 or 6° (1 minute) clockwise, test for play again. Repeat this move until you find a spot where the play almost (but not quite) disappears.



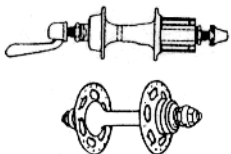


c) Find the Right Position - continued

- Finish the Adjustment by tightening down the Lock Nut against the Cone while holding the cone completely still (with the cone wrench!).
- Test the adjustment for play and grinding. (If it's a quick release (QR) hub you have to take it out of the vise, install the QR skewer, and clamp it down against either the frame or a set of drop-outs cut out of an old frame.)
- If it's too loose, hold the cone completely still while you unscrew the lock nut. Screw in the cone just 5° (1 minute) clockwise. Hold the cone completely still while you tighten the lock nut down against it again. Test the adjustment. If it's still too loose, repeat this step. If now it's too tight, hold the cone still, loosen the lock nut and carefully unscrew the cone 1/2 of the distance you just tightened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the cone still and check the adjustment again.
- If it's too tight, hold the cone completely still while you unscrew the lock nut. Unscrew the cone just 5° (1 minute) counterclockwise. Hold the cone completely still while you tighten the lock nut down against it again. Test the adjustment. If it's still too tight, repeat this step. If now it's too loose, hold the cone still, loosen the lock nut and carefully screw in the cone (clockwise) 1/2 of the distance you just loosened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the cone still and check the adjustment again.
- The most important ideas here are:
  - ◊ Don't lose your point of reference by letting the cone move as you loosen back up the lock nut, so you don't have to start all over again.
  - ◊ Tiny rotations of the cone make a big difference in the pressure on the bearings. How far are you moving the cone along the axle if you turn it, say, 1/4 turn (90° or 15 minutes)? Hint: there are probably 26 threads per inch (tpi) on the axle.

d) Reinstall the FreeWheel or Cassette, if you took one off.**9. Remount Wheel in Frame**

- a) Make sure it's centered (look at frame, not brake pads!)
- b) Make sure it's tightened (What could happen if your wheel falls off?)



**Remember:** Quick Release hubs - small amount of play before the wheel is locked in frame

Bolt-On hubs — no play



### **III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get each kid to put their finger on each of these parts on his/her bike & say the name.

#### **Hub**

Hub Flange  
Hub Cups  
Bearing Race  
Dust Cap

#### **Axle Set**

Axle: solid/hollow  
Cone  
Bearing Race  
Lock Washer  
Lock nut  
Axle Spacer

#### **Other**

Axle Nut  
Axle Washer  
Quick Release  
(QR) skewer  
Ball Bearings  
Bearing Retainer

#### **Necessary Tools**

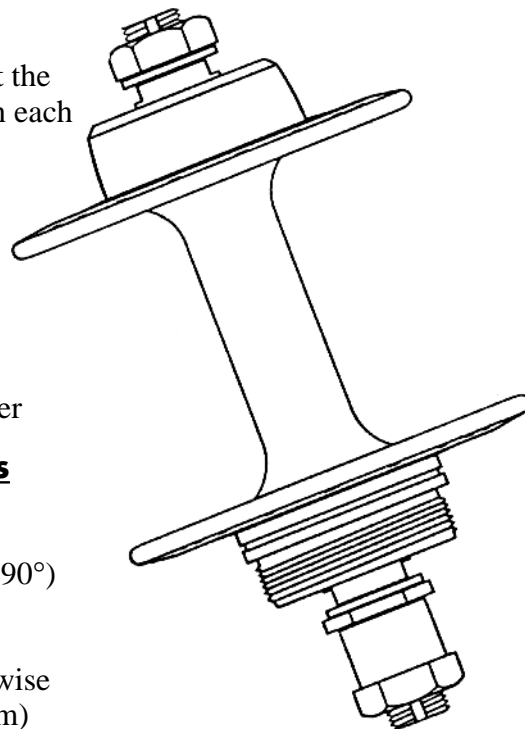
15 & 17 mm Combo  
Wrench (optional)  
Adjustable Wrenches  
Cone Wrenches  
Flat end Screwdriver  
Bench Vise  
Chain Whip  
Freewheel/cassette  
Remover

#### **Other Materials**

Grease  
Penetrating Oil  
Rags  
Rubber Gloves  
Ball Point Pen

#### **Math Words**

Diameter  
Length  
Perpendicular (90°)  
Parallel  
Clockwise  
Counter Clockwise  
millimeters (mm)  
tpi- Threads Per Inch



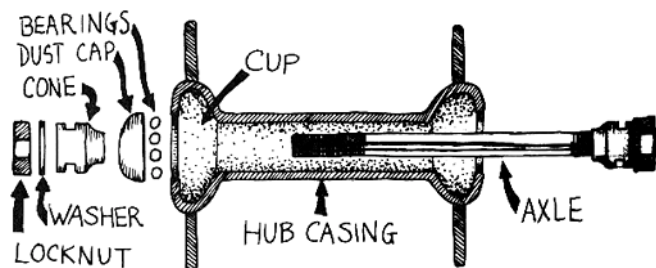
**Note:** The Hub and Axle Set are both part of the larger system called the Wheel or Pneumatic Suspension System. In this lesson you will also remove wheels, dealing with these parts from other systems on the bike: Drop outs, Rear Derailleur, chain, Fork.

### **IV. System Understanding** Try different ways of phrasing this question.

“What components are part of the rotational system in the hub?” “How do they interact/affect each other/work together? How do they function as a whole? What is the bigger system the Hub is a part of?”

### **V. Problem Solving/Diagnosis**

1. What does it mean if you get an adjustment that has both play and rough spots or grinding?  
What are the possible causes?
2. How can you tell if you need an overhaul?
3. If your hub became loose soon after you adjusted, what do you think the reason would be?  
How could you test your theory (guess)?
4. What other problem solving did we do?



### **VI. Review**

### **VII. Clean Up**

### **VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

<b>Selecting a Bike</b> .....	2
<b>Part One - Planning</b> .....	2
I. Objectives .....	2
II. Materials Needed .....	2
<b>Part Two - Activity Instructions</b> .....	2
I. Tool Check! .....	2
II. Process .....	2
III. Finishing Up .....	4
IV. Review .....	4



## Selecting a Bike

### Part One - Planning

#### I. Objectives

- A. Student knows which bike s/he will be working for and how many hours it will cost.
- B. Student is more aware of features that determine the value of a bike.
- C. Student becomes more familiar with the standards for fitting a bike.

#### II. Materials Needed

The primary materials needed are a good supply of potential bikes from which the student(s) can pick. If not all the bikes have wheels installed, there should also be a decent supply of wheels of every size that could be needed. You will also need tools to adjust seat and handlebar heights and perhaps to attach wheels.

### Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

#### II. Process

- A. **Goal** — We want the students to end up with a bike that will excite and motivate them throughout the rest of the course, but which will not cost so much that the students will get frustrated trying to finish up the needed hours.

- B. **Fit/Sizing** — What does the student remember from the safety video about proper bike fit?

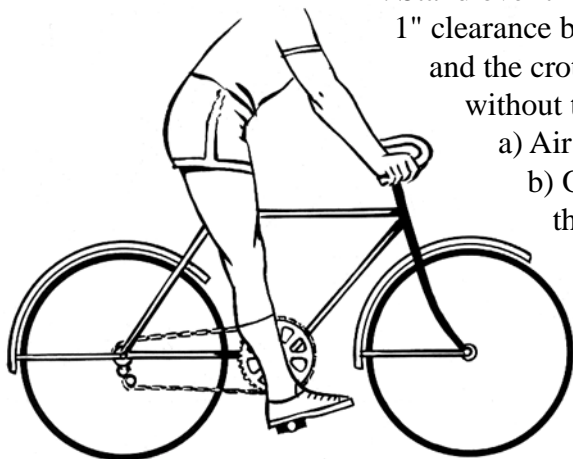
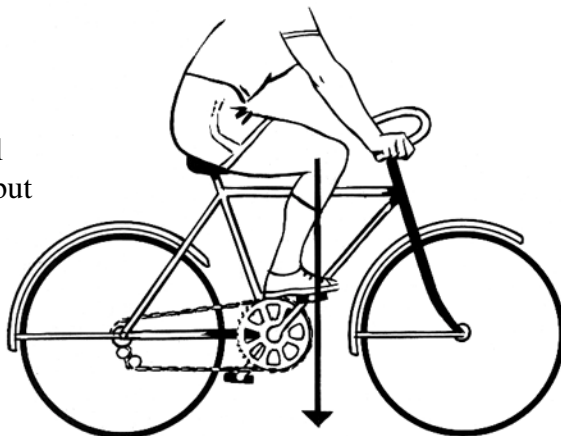
1. Stand over the bike. Is there at least 1" clearance between the top tube and the crotch? Can the student lift the front wheel at least 1" off the ground without the top tube touching him/her?

a) Air in tires?

b) Open frame bikes — Make sure both that the top tube, if it were there, would give adequate clearance; and that the student's leg is not overextended when the seat is in its lowest possible position.

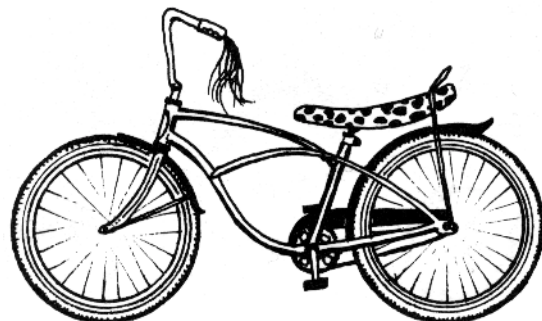
c) Don't let anyone get a bike that is too big!

2. Front to Back Reach — With your elbow on seat tip, your fingers should extend to handlebars, give or take an inch.

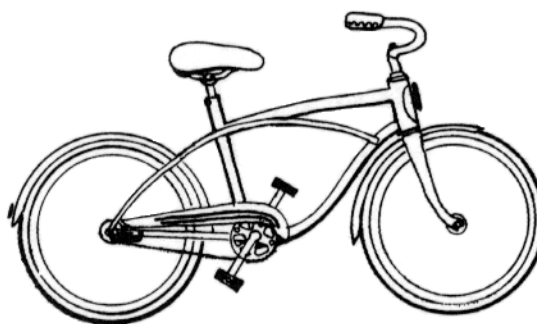


**C. Type of Riding** — What does the student want to do with this bike?

1. Handlebars — Any road bike can be fitted with upright bars — it'll add 5 hours to the cost of the bike.
2. Gears — You'll want them in order to do any serious riding. Push gears! We want EABers to experience their bikes as reasonable forms of transportation.
3. Tire width and tread type — Knobs slow you down on pavement, provide great traction in snow, mud or loose stuff. Students will have to pay cash for the knobby style tires which we have bought new (for 27 x 1 1/4" and 26 x 1 3/8" tires).



**D. Competition and Jealousy** — If more than one student wants the same bike (and it's an appropriate bike for each of them), have them draw straws.

**E. Cost**

1. While in EAB classes, students earn a credit of \$2/hour towards their bikes.
2. Accessories you add on later will cost. Suggest racks to people!
3. Desirability Factors  
Color, Condition of paint  
Style (Mtn. vs Road vs BMX)  
Frame quality (show them drop outs)  
Who knows???
4. Get the Lead Instructor to set the prices. Ranges are approximately:  
Road bikes, 10+ speeds: \$80 to \$130  
Low cost Mountain Bikes: \$80 to \$130 (e.g. Huffy, Columbia; depends a lot on wheels)  
BMXs: \$40 to \$100



Of course, there are plenty of used bikes in all of these categories that cost a lot more than the above ranges, but we do not recommend students take on really expensive bikes as their first EAB challenge.



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**III. Finishing Up — Seal the Deal**

- A. Label Bike
- B. Note Price on student's Time Sheet. Include notes on any parts not currently with the bike.
- C. Create a parts bag — Label a plastic bag with the students name, the date, and their phone number (on a tag, tied to the bag), and hang it from the handlebars.
- D. Make sure the students understands the prices. Do the math with them, and get them to figure out about how many weeks it's going to take to earn their particular bikes.

**IV. Review****V. Clean Up****VI. Tool Check!** Leave tool area as a group after confirming that all tools are present.



# Contents

<b>Bicycle Safety Skills</b> .....	2
<b>Part One - Lesson Preparation</b> .....	2
I. Objectives .....	2
II. Materials Needed .....	2
III. Setting .....	2
IV. Evaluation .....	2
<b>Part Two - Activity Instructions</b> .....	3
I. Tool Check! .....	3
II. Process .....	3
Steps to Safe Riding .....	3
Put Your Helmet on Correctly .....	4
Practice Riding in a Group .....	5
III. Language Skills .....	6
IV. System Understanding .....	6
V. Review .....	6



## Bicycle Safety Skills

### Part One - Lesson Preparation

#### I. Objectives

- A. Student can identify a bicycle that is unsafe to ride.
- B. Student can judge whether a helmet is being worn correctly, and is willing to wear a helmet.
- C. Student improves her/his ability to control the bicycle while executing skills necessary for in-traffic riding, such as riding in a straight line, looking over the shoulder for traffic without swerving, and using hand signals.
- D. Student learns to identify potential dangers in an intersection or street scenario, to make a plan to avoid them, and to execute the plan.
- E. Student becomes more familiar with the math concepts of perpendicular and parallel.



#### II. Materials Needed

##### Demonstration Parts

Helmet made for an egg  
Bike to use for Safety Check  
Bikes to be Ridden

##### Tools

TV and VCR  
Traveling Tool Kit  
Frame Pump

##### Other Materials

Chalk or Masking Tape  
2 Eggs, in Plastic Bags  
First Aid Kit

#### III. Setting

- A. Outdoor, Pre-Traffic Practice Area — playground, empty parking lot, or very quiet back street intersection. With chalk or masking tape set up two parallel lines on the pavement, one foot apart and at least forty feet long. At the end, make a mock intersection allowing room for a left turn off the parallel lines. Make sure there is enough room near the head of the parallel lines for the cyclists to assemble and wait their turns. See the BikeCentennial Bike Safety Rodeo manual for more setup ideas. You may have to sweep up glass, plan ahead!
- B. Outdoor, Practice Ride — choose routes to and from class meeting site that do not involve dangerous roads or intersections.

#### IV. Evaluation

- A. Teacher Observation During Work Session Observe the students you are working with for general riding skills (e.g. body position on start up, steadiness, stopping ability).
- B. Oral Review at end of work session.
  - 1) **Language:** How many of the parts and traffic terms can students identify? Passively? Actively?
  - 2) **Process:** How many of the steps of the safety check can students name? Can they get the steps in the correct order? How many of the steps of making a left turn can students name?
- C. Written Evaluation How well can student narrate what she did that day on her time sheet?

**NOTE:** While for simplicity sake we describe the Safety Skills lesson here as one lesson, it works best to divide these activities up and integrate them into mechanics lessons over the course of the entire EAB course. Riding provides a good break during mechanics, and can be used to reduce the number of students in your tool area at once.





## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### **II. Process**

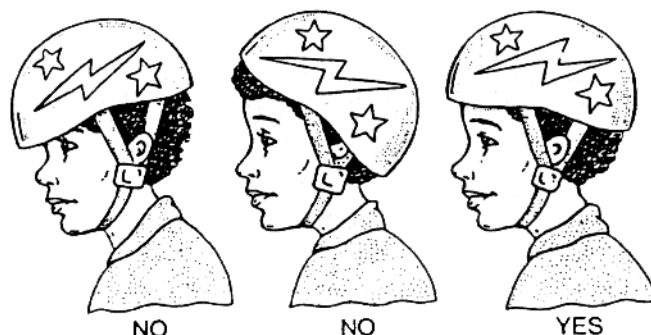
**A. Goal** — Group discussion: Have you ever had a bike crash or known anyone who has? What caused the crash? What were the consequences? Could it have been prevented? Allow time for people to tell possibly painful stories and describe their feelings - otherwise the students tend to numb out!

**B. Steps to Safe Riding** —

- 1. Watch a Safety Video** — it works best to view these a little at a time, 15-25 minutes maximum. The Videos available at Bikes Not Bombs are:
  - a) Bicycle Safety First A video of a slide show made for an adult audience, showing white adult riders in Oregon. Very good info. on the importance of lane positioning and tactics for riding in traffic. Works well with some young people.
  - b) Be Safe on Your Bike A California video, showing a mixed race group of boys riding in the suburbs. Good info., has an unnecessary boy meets girl theme.
  - c) Basics of Bicycling, Parts I, II, and III shows mostly younger children on BMXs, mostly white group, riding in what look like Mid-Western or New England suburbs. Has a good piece on making a plan to deal with potential obstacles.
  - d) Soon to be available: the Bikes Not Bombs Girls In Action Bike Safety Video!
- 2. Evaluate Condition of Your Bike** — do the Safety Check!
  - a) Drop the Bike from a few inches off the ground, letting it bounce a bit on its wheels. Listen! Anything loose? Pay special attention to the Headset.
  - b) Check the Wheels — Is there side to side play. If so, is it in the hub adjustment or is the wheel loose in the dropout? Do both wheels spin freely?
  - c) Is there enough air in the tires? You shouldn't be able to dent the tire w/your thumb.
  - d) Do the brakes stop the bike? Squeeze both brake levers and try to push the bike forward. Try to push it backwards. The wheels shouldn't turn.
  - e) Can you rock the Crank Arm from side to side? If you could, what would that mean?
  - f) Your Body and Clothes! Any loose shoe laces, baggy pants that might get caught in the chain or wrapped around the pedals? Or long hair that might get in your eyes?

**3. Put Your Helmet on Correctly**

- a) Do the Egg Drop Demo. Draw a little face on an egg, name it, and see what happens to it when you drop it to the pavement (covered with a sheet of paper!) from one foot high. Then put the second egg (also named!) in it's "helmet" (and inside a plastic bag). Drop it from one foot. Did it break? Drop it from two feet. Did it break? Keep dropping it from one foot higher each time until it breaks. Describe the straps securing the egg helmet as having the same role as your helmet chin strap & buckle. Point out both that the helmet protected it a lot, and that a hard enough blow will break your head even with a helmet.
- b) Put in Pads that make your helmet fit snugly on your head. No side to side or front to back play, but not squeezing your head.
- c) Adjust Straps so that you can't push the helmet up to expose your forehead, or forward to expose the back of your head.

**Bicycle Helmet Fit****4. Practice Basic Skills Away From Traffic**

- a) Riding in a Straight Line — Can you stay between two parallel stripes one foot apart?
- b) Riding in a Straight Line while Looking Over your Shoulder — Can you look and then say how many fingers the instructor behind was holding up, without swerving outside the parallel lines?
- c) Riding in a Straight Line while Using hand Signals Can you make a "right turn" or "left turn" or "stopping" signal, without swerving outside the parallel lines?
- b) Riding in a Straight Line while Looking over your Shoulder and Signaling! Can you look and then say how many fingers the instructor behind was holding up, and make a hand signal, all without swerving outside the parallel lines?
- d) Making a Left Turn Combine all of the above and turn left at the end of it, into a perpendicular street that has been drawn on the pavement. For the more sophisticated, work on positioning in the lane once they master a simple left turn.

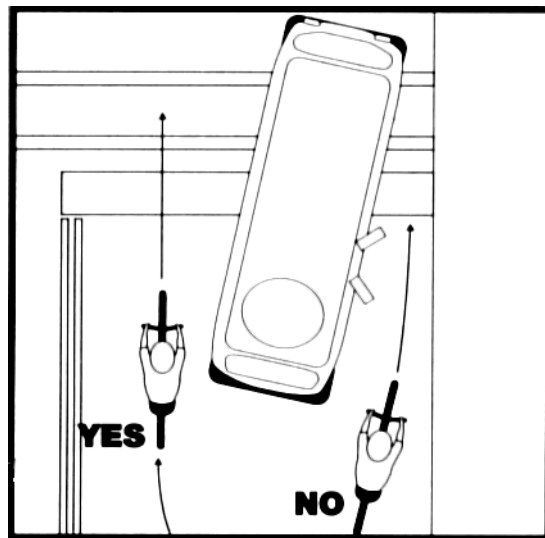
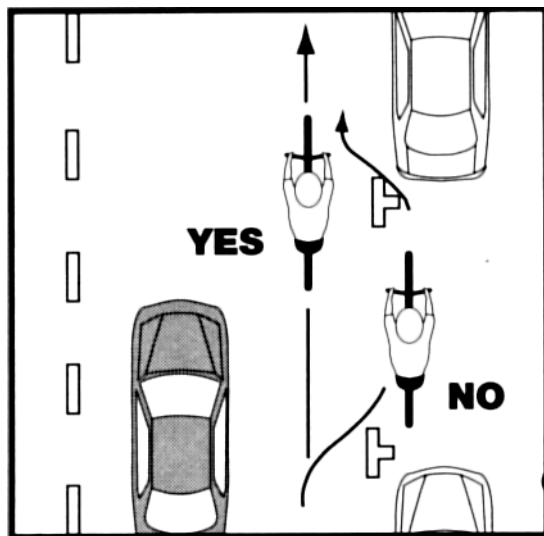


**5. Practice Riding in a Group, Away from Traffic** Try a first ride on a bike path. Take a first aid kit, a tool kit, a pump and some water. Stop occasionally and ask how your riders are doing. Ask what has been going well. Ask if anyone noticed anything that needed improvement.

- a) Everyone Thinks for Themselves Don't go through an intersection just because the person in front of you did!
- b) Establish an Order of Riders On the first group ride it may be necessary to keep everyone in the original order and not allow passing, depending on how much self-control and attention the riders have. Eventually allow passing, only if you look behind you, and warn the rider you're about to pass.
- c) Don't let the Person Behind You get Out of Sight. Watch out for the group and don't leave anyone behind.
- d) Pull your Bike Over to the Side of the Road or Path if you have to Stop.
- e) If you are riding on a bike path parallel to a road, when crossing a side street, Be Careful to Look Over Your Shoulder for Cars coming Up behind you, About to Turn Right or Left across the bike path on the side road!

**6. Go for a Ride In Traffic!** Choose both your group and the route carefully. You probably want to start with a group of only three or four students and two instructors.

- a) Ride up to a busy intersection, stop and Strategize How to get Across. Where are all of the places cars could come from? What would happen to your plan if suddenly a cyclist shot out of somewhere, going the wrong way or running a red light?



- b) Try it Out! Send one person at a time, don't send anyone who's not ready. Remember that walking a bike across an intersection in the cross walk is always a fine option.
- c) Watch out for Car Doors — stay far enough out in traffic to avoid an opening car door. How far is that? Go out and measure the width of a few doors.



### **III. Language Skills**

Over the course of the safety lessons we should introduce all of these terms. At the end of the session it is often helpful to get each student to touch each of these parts on his/her bike & say the name.

#### **Main Part**

Helmet  
Reflector

#### **Minor Parts**

Helmet Liner  
Helmet Shell  
Helmet Buckles

#### **Traffic Terms**

Intersection  
Right of Way  
Yield  
Lane  
Stop Line  
Pedestrian

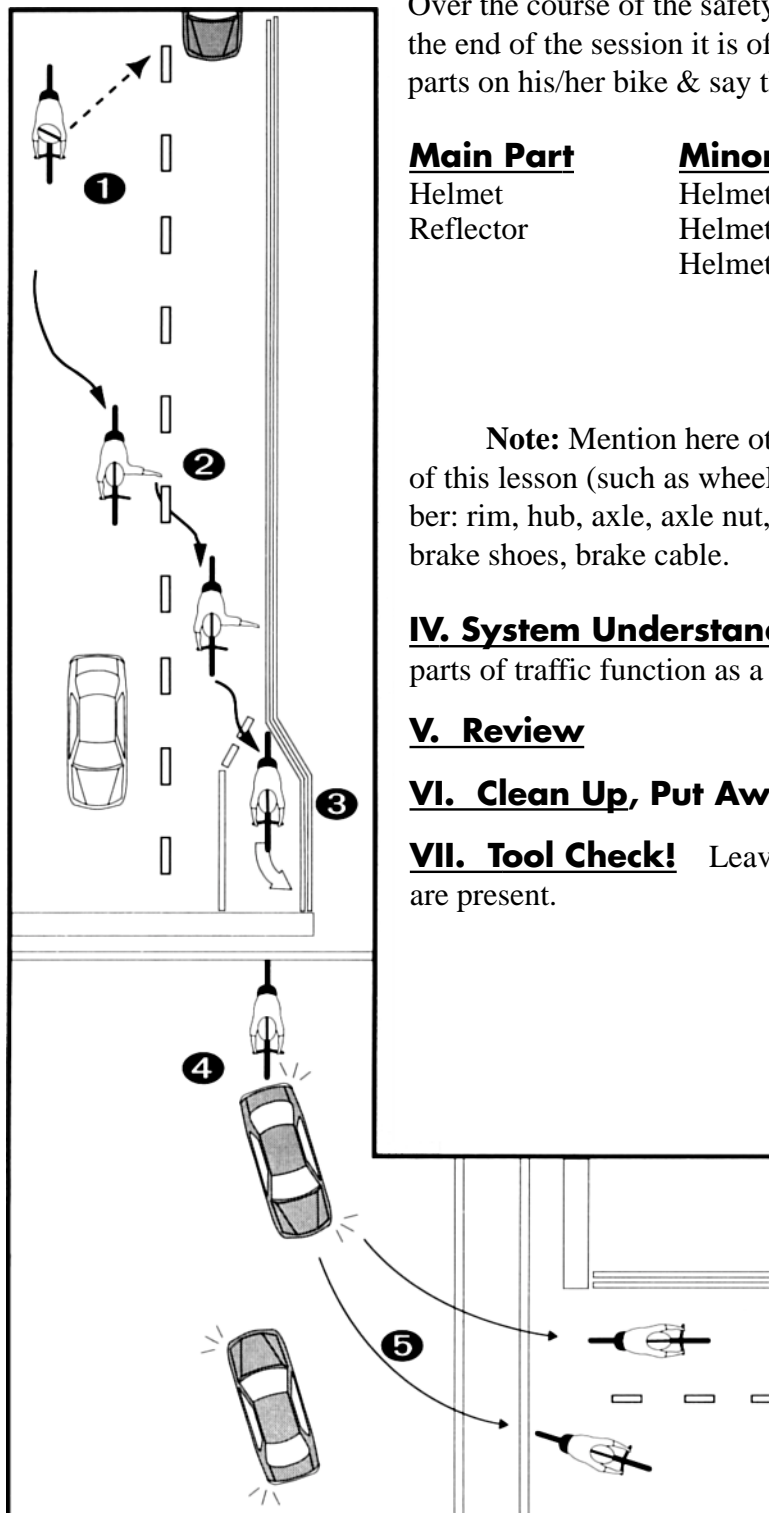
**Note:** Mention here other systems you end up dealing with in the course of this lesson (such as wheels or brakes), and include the main words to remember: rim, hub, axle, axle nut, quick release skewer, brake lever, brake caliper, brake shoes, brake cable.

**IV. System Understanding:** Is traffic a system? How do the different parts of traffic function as a whole? What is a transportation system?

### **V. Review**

### **VI. Clean Up, Put Away Bikes and Helmets**

**VII. Tool Check!** Leave tool area as a group after confirming that all tools are present.





# Contents

## **Rotational Systems — Headset Overhaul & Adjustment ... 2**

### **Part One - Preparation ..... 2**

I. Objectives .....	2
II. Materials Needed.....	2
III. Setting .....	2
IV. Evaluation .....	2

### **Part Two - Activity Instructions ..... 3**

I. Tool Check! .....	3
II. Process .....	3
III. Language Skills .....	5
IV. System Understanding .....	6
V. Problem Solving/Diagnosis .....	6
VI. Review .....	6

## **Rotational Systems: (Quiz/Review) ..... 7**



## Rotational Systems — Headset Overhaul & Adjustment

### Part One - Preparation

#### I. Objectives

- A. Reinforce basic concepts of correct tool use.
- B. Review rotational systems and bearing adjustments. Students should be able to describe what a good bearing adjustment is and why, and relate headset parts to the equivalent bottom bracket and hub parts.
- C. Reinforce the math concepts of parallel and perpendicular lines.
- D. Reinforce physics concepts of friction as a type of force.

#### II. Materials Needed

##### Demonstration Parts

Fork mounted in a head tube cut out of a bike frame  
Fork, out of bike, with stem mounted in it  
Loose fork w/locknut and adjustable cup  
Pitted races, cups  
Loose stem

##### Tools

Hook spanner/Lockring wrench  
Headset wrenches  
Slide hammer  
12" Adjustable Wrench  
Crown race remover  
Headset Press  
Allen wrenches  
Combination wrenches  
12" Channel-lock pliers

##### Other Materials

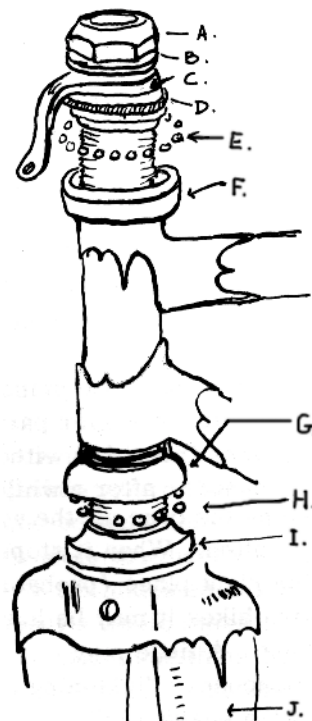
Grease  
Penetrating Oil  
Rags  
Rubber Gloves  
Ball Bearings

**III. Setting:** Workshop, with tool benches, bike repair stand and bike storage.

#### IV. Evaluation

- A. Teacher Observation During Work Session
- B. Oral Review at end of work session.
  - 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) **Systems:** Can the student say what components are part of the system on which we've been working? How do these components function together as a whole?
  - 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- C. Written Evaluation How well can student narrate what she did that day on her time sheet?
- D. Test — Make copies of the diagram at right and have students fill in the names of the parts.

**A. Locknut B. LockWasher C. Cable Hanger D. Adjusting Cone**  
**E. Bearings F. Top Frame Race (or cup) G. Bottom Frame Race (or cup)**  
**H. Bearings I. Fork Race J. Fork Blade**





## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

### II. Process

**A. Goal** — The main purposes of each of the bike's rotational systems are: 1) to allow rotation (turning) without a lot of friction and with no side-to-side play; and, 2) to bear weight. A well done headset job also makes sure that:

- your bike has nothing in the headset system that is about to get destroyed or come out (stem not in far enough, head tube not getting “ovalized,” etc.)
- the headset isn't going to go out of adjustment again soon (due to cup/cone not being locked in place, or due to pressed in cups being loose in head tube)
- your front brakes work without the sudden jerking that comes from a loose headset

**B. Steps to Overhaul a Headset** — Go over the name of each step, as a list. Then describe each step to the students and have them each carry out that step on their bike before you move the group onto the next step.

**1. Evaluate Condition** of existing parts before disassembling. Check the adjustment. Does everything fit together well? Do the bottom edges of the crown race and the pressed in races all appear perpendicular to the head tube? Is the fork visibly bent? Make an initial decision about what to replace.

#### 2. Disassemble

a) Remove the Handlebar-Stem assembly

- Unscrew the stem binder bolt until it lifts away from the top of the stem  $\approx 1/4$ "
- Tap the top of the stem binder bolt with a hammer to drive the wedge down out of the top of the fork column.
- Pull up on handlebars and stem, removing the stem from the fork column. Detach front brake cable if necessary. Hang handlebars on bike.

b) Remove the front wheel (why wait until now to remove wheel??)

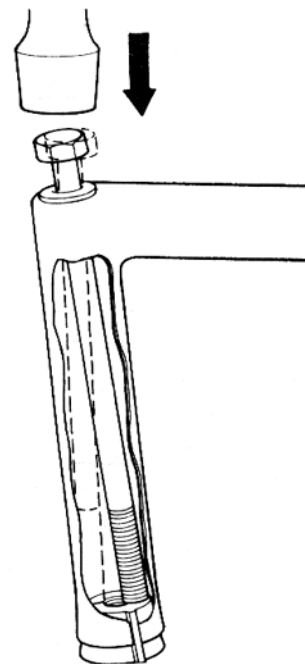
c) Unlock the headset locknut from the race directly under it, unscrew the locknut and the adjustable race all the way, holding up the fork with your other hand so it won't drop out of the bike!

d) Stack up all parts in the order in which you take them off.

e) Pull out the fork from the bottom of the head tube, catching any falling bearings with your hand.

f) Remove any bearings that got left behind in the races that are pressed into the head tube (the “pressed in races”).

**3. Clean and inspect** all the bearing surfaces and threads, looking for pits or scratches on the races, bearings or cups. Remove the pressed in races if they are loose or if they need to be replaced. Put the fork in the fork jig to see if it's bent.

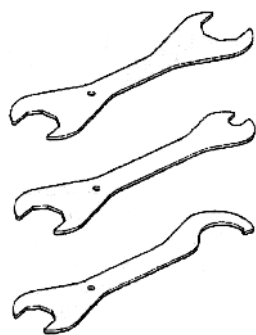




**B. Steps to Overhaul a Headset** - continued

- 4. Replace Parts** as necessary and possible! It is hard to mix and match parts from different headsets. What are some of the dimensions (sizes/diameters) that have to be exactly the same? If you don't have a replacement for a pitted race or cup, go ahead and reassemble with lots of new clean grease and new ball bearings. You'll get a better bearing adjustment than you started out with, though not perfect.

**5. Reassemble** — this is just disassembly in reverse.

**Headset Wrenches**

- Reinstall pressed in races** if you removed them, using press or a hammer on the flat handle of a headset wrench placed across the race. If they were loose, shim them with pieces of an aluminum can.
- Grease the cups** putting a good thick layer in the back of each.
- Install Bearings** If the bearings are in a retainer, check which side faces the cone! If you are using loose ball bearings, fill up the race with a complete ring and then remove two balls.
- Replace crown race** on the fork, if you removed it. If it was loose, shim it with pieces of an aluminum can. Use the slide hammer to get it on tight, all the way down, and parallel to the fork crown.
- Reinstall the fork**, screwing on the adjustable race, washer, any spacers, and the first locknut/locking finger tight.
- Ready to adjust!

- 6. Adjust the bearings** — the same basic “not too loose, not too tight” idea as other bearing systems on bike, but your fork is not spinning at 40-100 rpm like your wheel hubs or you bottom bracket spindle. Therefore slightly tight is not as much of a problem as in wheels or bottom brackets.

- Find Out How Good an Adjustment You Can Get** With fingers or tools, screw the adjustable race up and down on the fork column until you find a spot where the adjustment is both not too loose and not too tight.
- Get the Adjustable Race Locked in the Correct Position** If you were just to tighten down the locknut against the race at the “perfect adjustment spot” you just found, the tightening of the locknut will tighten the adjustment slightly, even if you are careful not to let the adjustable race rotate on the fork threads. (Why? How is this similar to the hub adjustment?)
  - starting at the “best adjustment position” you found for the adjustable race in the previous step, carefully loosen the race 30 to 60° (5-10 minutes, thinking of a clock)
  - hold the adjustable race in place, not letting it or the fork rotate, and tighten down the lock nut against the adjustable race. (To hold the fork still, reinstall the front wheel, and hold it between your legs as you do the adjustment.) Test the adjustment for play and grinding.
  - If it's too loose**, hold the adjustable race completely still while you unscrew the lock nut. Screw in the race just 5° (1 minute) clockwise. Hold it (and fork!) completely still while you tighten the lock nut down against it again. Test adjustment. If it's still too loose, repeat this step. If it's too tight, hold the race still, loosen the lock nut and carefully unscrew the race 1/2 of the distance you just tightened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the race still and check the adjustment again.



**6. Adjust the bearings** - continued

- If it's too tight, hold the adjustable race completely still while you unscrew the lock nut. Unscrew the cone just 5° (1 minute) counterclockwise. Hold it completely still while you tighten the lock nut down against it again. Test the adjustment. If it's still too tight, repeat this step. If it's too loose, hold the race still, loosen the lock nut and carefully screw in the race (clockwise) 1/2 of the distance you just loosened it (about 2 1/2° or 1/2 minute). Tighten down the lock nut while holding the race still and check the adjustment again.
- If there is a second locknut, tighten it down against the first locknut/locking.
- The most important ideas here are:
  - ◊ Don't lose your point of reference by letting the adjustable race or the fork column move as you loosen back up the lock nut, because you'll have to start all over again.
  - ◊ Tiny rotations of the race make a big difference in the pressure on the bearings. How far are you moving the race along the fork column if you turn it, say, 1/4 turn (90° or 15 minutes)? Hint: How many threads per inch (tpi) are there on the fork column?

**7. Reinstall the Handlebars and Stem****III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to get each student to touch each of these parts on his/her bike & say the name.

**Handlebar-Stem System**

Handlebars (HBs)  
Stem  
Stem Binder Bolt  
HB Binder Bolt  
Stem Binder Bolt Wedge  
Grips or HB Tape

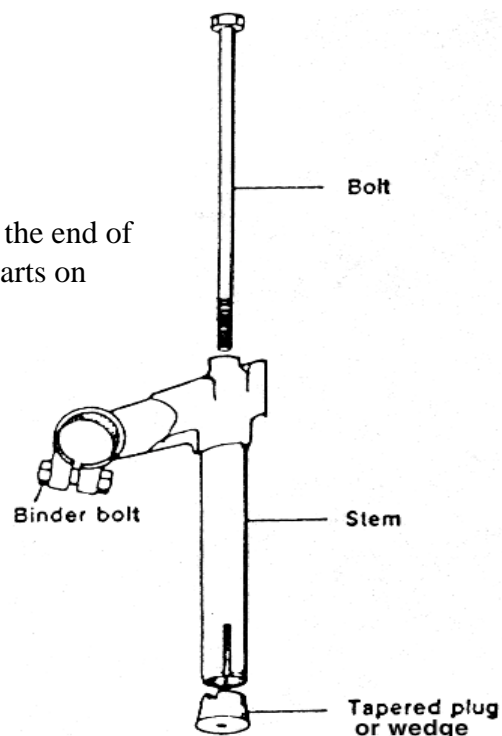
**Fork**

Fork Blades or Tines  
Fork Crown  
Drop-outs  
Fork Column  
Head Tube (frame part)

**Head Set**

Crown Race  
Adjustable Race/Cup  
Pressed-In Cups (Upper and Lower)  
Washer (with or without key)  
Lockring\*  
Locknut  
Bearing Retainers  
Ball Bearings  
Brake Hanger\*  
Reflector Bracket\*  
Headset Spacer\*

\* Not included in all headset arrangements



**The Headset -  
Stem Parts**

**III. Language Skills** - continued**Specialty Tools**

Headset wrenches  
Hook spanner/  
Lockring wrench  
Headset Press  
Slide hammer  
Crown race remover

**Common Tools**

Hammer  
Flat End Punch  
Allen wrenches  
12" Adj. Wrench  
Combo. wrenches  
12" Channel lock pliers

**Math Words**

Diameter  
Length  
tpi-threads per inch  
millimeters (mm)  
Parallel  
Clockwise  
Counter Clockwise  
Perpendicular - 90°

**Materials**

Grease  
Rags  
Penetrating Oil

**IV. System Understanding** Try different ways of phrasing this question.

“What components are part of the Headset system?” “How do they interact/affect each other/work together?”  
“How do the components function as a whole?” “What is the bigger system the Headset is a part of (Steering system)?” “What are the parts of the Steering System?”

**V. Problem Solving/Diagnosis**

- A. What are three possible causes of play felt when you try to rock the fork column from front to back in the head tube? How could you figure out which is the actual cause?
- B. If you are trying to adjust a headset perfectly, and you get both play (looseness) and some grinding (tightness) at one single position of the adjustable race, what are some possible causes? How could you figure out which is the actual cause?
- C. What other problem solving did we do?

**VI. Review****VII. Clean Up****VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.



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## Rotational Systems: (Quiz/Review)

1. What are the symptoms that would require replacement of parts in Rotational Systems?
2. Describe how the locking systems work in each of the Rotational Systems studied.
3. How would a bent axle affect a hub's performance?
4. Where do you check for wear in Rotational Systems?
5. What happens when bearing systems are adjusted too tightly? too loosely?
  - 5a. If running out of time or patience (student or teacher), is it better to leave adjustment a little too tight or a little too loose?
6. How can you be sure not to install a bearing retainer backwards?



# Contents

## **Suspension System: Wheel Truing & Spoke Tension ..... 2**

### **Part One - Planning ..... 2**

I. Objectives ..... 2

II. Materials Needed ..... 2

III. Setting ..... 2

### **Part Two - Activity Instructions ..... 3**

I. Tool Check! ..... 3

II. Process ..... 3

    Steps to Truing Wheels ..... 3

    Truing ..... 4

    Checking and Correcting Dish ..... 6

III. Language Skills ..... 7

IV. System Understanding ..... 7

V. Problem Solving/Diagnosis ..... 7

VI. Review ..... 7



## **Suspension System: Wheel Truing & Spoke Tension**

### **Part One - Planning**

#### **I. Objectives**

- A. Student can identify the difference between a warped rim and a loose hub.
- B. Student can understand the basic concept of truing.
- C. Student can determine when a rim is bent (not fixable) versus having improper spoke tension (fixable).
- D. Student becomes more familiar with the math concepts of perpendicular and parallel.
- E. Student can name the parts of the wheel and the tools involved in the process of wheel truing.
- F. Student gets a background lesson that will assist in future learning about resolving force vectors into X and Y components.

#### **II. Materials Needed**

##### **Demonstration Parts**

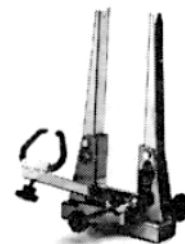
Variety of Wheels in various states of True/Out of True  
Spoke and Nipple, not installed

##### **Tools**

Truing Stand  
Metric Ruler  
Spoke Wrenches  
Freewheel Removing tools  
Dishing Tool  
Vice Grips  
Bench Vise

##### **Other Materials**

Grease  
Penetrating Oil  
Rags



**Truing Stand**

**III. Setting** Workshop, with tool benches, bike repair stand and bike storage.

#### **IV. Evaluation**

- A. **Teacher Observation During Work Session** Rotate amongst the students as you work. Observe for general mechanics skills (e.g. body mechanics, tool use), work habits (e.g. keeping part orderly, replacing tools), and ability to follow the steps of the process in the proper order. Observe for problem solving skills: Is student using visual observations? Is student able to pose questions whose answers will help her come up with a solution?
- B. **Oral Review at end of work session.**
  - 1) **Language:** How many of the parts and specialty tools can students identify? Passively? Actively?
  - 2) **Systems:** Can the student say what components are part of the system worked on? How do they function as a whole?
  - 3) **Process:** How many of the steps of the process can students name? Can they get the steps in the correct order?
- C. **Written Evaluation** How well can student narrate what she did that day on her time sheet?



## Part Two - Activity Instructions

**I. Tool Check!** Students & instructors enter the tool area and confirm as a group that all the tools are there.

## **II. Process**

**A. Goal** — What are we trying to get done when we true a wheel? What are the necessary steps that must be accomplished with all wheels before we can begin the process of truing?

**B. Steps to Truing Wheels** — Go over the names of each step, as a list. Then describe each step to the students and have them each carry out that step on their bikes before you move the group onto the next step.

**1. Evaluate Condition** of as many parts as possible before disassembly:

- a) Check Adjustment of Your Hubs Before we can begin the process of truing our wheels we must make sure that our hub is properly adjusted. If the hub bearing assembly is loose, the whole wheel (and the rim!) will move back and forth in the truing stand whether or not the rim is true.
- b) Spokes It's no good to attempt to true a wheel with broken spokes. In many cases a broken spoke is the reason why a wheel will go suddenly out of true. Measure the length (in mm) of a spoke on the same side of the rim as the broken spoke. You do this by measuring from the center of the head of the spoke to about the center of the nipple.

It is also important to check the condition of the spokes and the nipples. If these are too rusty there is a good chance that the spokes will not be able to turn inside of the nipple. This will prevent you from truing your wheel. You will recognize this condition if you attempt to turn the nipple and the spoke turns with it. A possible way to remedy this situation is to drip oil in between the nipples and the spokes and let it soak. Come back later and see if things have loosened up any.

- c) Rim Condition Is the rim really rusty? What about bent? Remember, steel rims can be bent back into shape, aluminum rims cannot. Also look for serious divots in the rim. An aluminum rim with a serious divot is ruined. A steel one might be able to bend back into shape. Also, if the wheel wobbles more than 3 inches in either direction there's a good chance that it cannot be fixed.

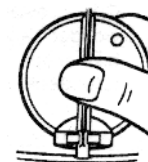
If the spokes look like they are in good condition and the rim doesn't seem to be bent you can begin the process of truing your wheels.

**2. Truing**

- a) Take the Wheel off the Bike
- b) Put the Wheel in the Truing Stand There are a lot of different types of truing stands out there. A lot of at home mechanics use the brake pads on the bike as a truing stand and just true the wheel on the bike. However, if a stand is available, use it! The industry standard is the Park Truing Stand, which we highly recommend. It's durable, very adjustable, and just about everyone uses it, so you can always get parts.



- c) Pick out your Spoke Wrench If you pick the right wrench you won't ruin your wheel. Without the proper spoke wrench size there is a very good chance that you will strip the nipple as you attempt to turn it. Once the nipple is stripped, no more truing. Make sure the spoke wrench fits very tightly around the nipple. If it looks like you might be stripping the nipple (the wrench is turning but the nipple is not), STOP!!!! Change your spoke wrench or see if the nipple is too rusty to move at all.



- d) Begin Truing OK. Now that you've done all the easy stuff, here comes the hard part. Truing wheels has got to be the closest thing to an art form in the arena of bike mechanics. Those that are great at it are revered as gods. Those that are not good at it live life frustrated and angry. (Just kidding.) Seriously though, truing is much more difficult than any other task on a bike. It takes a certain "touch" that only comes with a lot of experience. Beginners will succeed to the extent that they get down the repetitive steps and the concept of making the rim straighter little by little. Here is a starting point and remember: Practice makes Perfect.

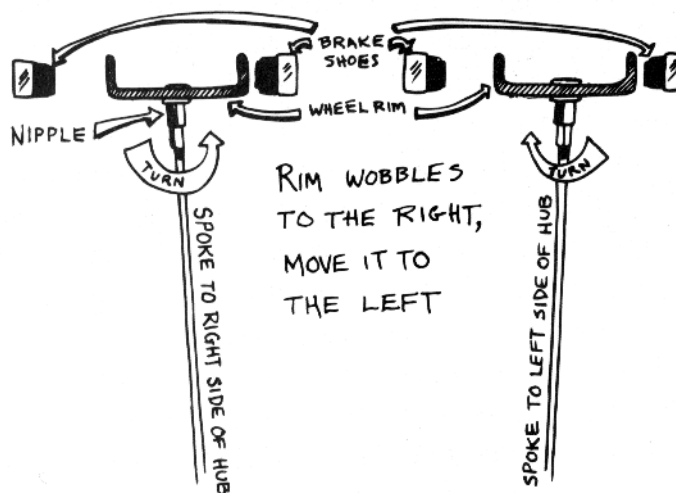
Step 1 Find the Worst Spot: Once your wheel is locked into the stand, spin the wheel lightly and begin to screw in the stand's caliper arms gradually until one of the caliper arms just barely brushes the side of the rim. You will hear a "Ping" whenever that part of the rim passes by the caliper. What you don't want to do is screw in the caliper arms so quickly that they contact the rim so quickly and so hard that you hear "SCREEEEEEEE" and the wheel stops moving. Nor do you want to screw it in so far that the caliper arm touches the wheel more than once per revolution. You are looking for the worst spot (the place the rim is farthest off to one side), not the several worst spots.

Step 2: Identify on Which Side the Rim is Out of Line. Now that you've found the "Ping" you know that this is the spot of the rim that is the farthest out of true. Identify the three or four spokes right next to the "Ping" and which side of the rim is rubbing on the caliper to create the "Ping."

Step 3: Decide Which Spokes to Tighten. You need to pull the rim at the "Ping" spot back in towards the center line of the wheel, in order to start to "flatten out" this bulge/warp in your rim. To move the rim you will tighten some of those 3 or 4 spokes you've picked out. Trace the spokes from the rim back up to where the spoke heads are attached to the hub flange. Notice which of your 3 or 4 spokes are attached to the opposite side of the flange from the side where the "Ping" is rubbing on the stand's caliper arm – these are the ones you want to tighten, since they will pull the rim which bulges a bit in that direction a bit back into line.

d) Begin Truing - continued

Step 4: Tighten the Spokes that coincide with the “Ping” and that are attached to the opposite side of the hub flange than the part of the rim that is warped. Always tighten only 1/4 turn of the spoke wrench at a time. Often you will only have to tighten spokes as you are truing. The only time you want to loosen a lot of spokes much is when the spoke tension is high around the entire wheel. However, if after you tighten the spokes that will pull the “Ping” back into line, twang the 1 or 2 spokes at the “Ping” that are pulling in the other direction. If they seem much tighter than the 1 or 2 spokes you just tightened, loosen these spokes by 1/4 turn also.



Step 5: Go back to Step 1 and find the “Ping” that identifies the spot that is now your worst spot (it may be the same spot, or, if your adjustment at the 1<sup>st</sup> “Ping” brought the rim enough back into alignment, you may now have a new worst spot). Repeat the above steps until you’ve gotten the wheel straight enough so that the rim doesn’t scrape the calipers at all when you have them set about as far from the rim as you would like to have your brake shoes set. Small gradual changes are the secret to getting a strong, straight wheel!

e) Pre-Stress the Wheel Once your rim seems true enough, you need to pre-stress it. As you ride a bike the rolling wheels are under constantly changing stresses. Sometimes as a spoke goes from being under tension to being released from tension as the wheel rotates when you first ride the bike after truing the wheel, spokes or nipples will rotate slightly and settle into a new position. Your wheel might end up out of true again. To avoid this, pre-stress your wheel while you are still in the shop.

Step 1: Take it out of the truing stand and put it on the ground, vertically.

Step 2: Lean all your weight down onto the top of the wheel.

Step 3: Rotate the wheel about 1/8<sup>th</sup> of a turn and lean on it again. Do this all the way around the rim. You will probably hear some snapping and popping sounds which are the spokes settling in.

Step 4: Put the wheel back in the stand and check to see if it’s still true. If not, go back to the truing steps.





### 3. Checking and Correcting Dish

All rims must be centered over the center of the axle in your hub in order for the wheel to run centered in the bike frame. A wheel that is centered in this way has the right “dish” to it. A wheel can be true, i.e. no warps from left to right, and still not work because it is not properly dished and therefore won’t sit in the center of the forks or the rear stays. *At Bikes Not Bombs we don’t usually teach dishing unless a student has grasped truing with some ease. If the wheel is so out of dish that the braking or gears systems will be affected, we usually have an instructor fix it after class.*



**Dishing Tools**

- a) Take your dishing tool and place it so that the ends of the arms rest flat on the rim on opposite sides of the wheel. This can only be done with the tire off or fully deflated. Adjust the dial-in arm of the tool until it just barely touches the top of the lock nut on the axle.
- b) Now take the tool off and flip the wheel over. Put the tool back onto the rim. If the dial-in arm does not touch the lock nut on the opposite side of the wheel in exactly the same way, your wheel is not dished properly.

- c) Dishing the Wheel If your wheel is not dished properly you’ll need to tighten and loosen all the spokes in an alternating pattern until the wheel is dished properly.

Step 1: Determine which way you need to pull the rim in order to get the rim centered over the center of the axle. (Think about it for a moment – when the wheel is correctly dished, the dial-in gauge will touch the locknut on the 2<sup>nd</sup> side perfectly once you’ve adjusted it to touch the locknut on the 1<sup>st</sup> side.)

Step 2: Determine which spokes you have to tighten and which to loosen. The spokes to tighten are those that are attached to the hub flange on the side of the wheel towards which you need to move the rim. Going along the rim, you will find that every other spoke needs to be tightened.

Step 3: Adjust 1/2 of the spokes. Starting at the inner-tube valve hole in the rim, take the 1<sup>st</sup> pair of spokes and loosen the one to be loosed 1/4 turn. Then tighten the other one 1/4 turn. Now skip the next two spokes. Take what is now the 3<sup>rd</sup> pair of spokes (or the 5<sup>th</sup> and 6<sup>th</sup> spokes from the hole), and tighten and loosen them each their respective 1/4 turn. Proceed in this manner, skipping every other pair of spokes, until you get all the way back to the rim hole.

Step 4: Adjust the other 1/2 of the spokes: Now skip the first pair of spokes (the 1<sup>st</sup> and 2<sup>nd</sup> spokes, which you already adjusted on the last pass), and go ahead and adjust the second pair (the 3<sup>rd</sup> and 4<sup>th</sup> spokes from the hole). Proceed all the way around again, until you get back to the valve hole. Now, if you kept track(!), you should have tightened, by 1/4 turn, all the spokes that are attached to the hub flange on the side of the wheel towards which you need to move the rim, and loosened, by 1/4 turn, all the others.

Step 5: Check the dish again with the dishing tool. It should have gotten better! If it’s worse, you tightened the wrong side. If it’s still not right, do steps 1-4 again.

Note: Rear wheels with gears don’t have the rim centered over the middle of the hub. They are centered over the axle and have a “flat side of the wheel,” the side the gear cluster is mounted on, where the spokes are all pulled in tighter in order to make room for the gear cluster.

**III. Language Skills**

Over the course of the lesson we should introduce all of these terms. At the end of the session it is often helpful to have the students touch each of these parts on their bikes & say the name.

**Main Part**

Rim  
Spokes  
Nipples  
Hub  
Axle  
Tire  
Tube

**Minor Parts**

Ferrules  
Spoke Head  
rim strip  
Flange  
Drop out

**Necessary Tools**

Truing Stand  
Metric Ruler  
Dishing Tool  
Spoke Wrenches  
Adjustable or Box End Wrenches  
(to remove wheel)

**Other Materials**

Grease  
Light oil  
Rags

**Math Words**

Circumference  
Radius  
Tension  
Torque  
Centrifugal Force  
Triangulate

**Note:** Mention here the other systems you end up dealing with in the course of this lesson (e.g. the brake system), and include the main words to remember.

**IV. System Understanding** Try different ways of phrasing this question.

What components are part of this wheel system? How do they interact/affect each other/work together? How do they function as a whole?

**V. Problem Solving/Diagnosis.**

1. What does it mean if your wheel is out of true?
2. How can you tell if the wheel can be trued or is unfixable?
3. How do you know which spokes to tighten or loosen when truing a wheel?
4. What other problem solving did we do?

**VI. Review****VII. Clean Up****VIII. Tool Check!** Leave tool area as a group after confirming that all tools are present.